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Construction Methods

MES RIVER
BRIDGE
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sixteen two-rib
arch spans
mnerected by
eling derricks

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LE TOURNEAU

MODERN EQUIPMENT

ON

The GREAT DAMS and NATIONAL PARK HIGHWAYS

The Photographs

Above. One of a fleet of three 30 Yard Buggies on the Bonneville Dam. Oregon-Washington.

Left. One of the 12 Yard Super Carryalls on the Mt. Lassen National Park Highway. California.

Right. Bulldozer doing all the sloping on one of the Yellowstone National Park Highways. Wyo.

Below. Three 12 Yard Carryalls stripping on the site of the great Coulee Dam, Washington.

Le Tourneaus ability to move more material at less cost per yard—faster—under all types of conditions is only one of the reasons why they are at work on all the great dams and major highway projects of the country.

Our Engineering Department will tell you by photograph, data sheets—facts and proven figures all about the Le Tourneau methods of excavating with this modern equipment.

R. G. LE TOURNEAU, INC.

P. O. Box 1290 **STOCKTON, CALIFORNIA**

TECHNOLOGY DEPT.

Construction Methods

McGraw-Hill Publishing Company, Inc.,
330 West 42nd St., New York

ROBERT K. TOMLIN, Editor

OCTOBER, 1934

WILLARD CHEVALIER, Vice-President

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New Explanations of Construction Code

● Six more explanations of code provisions, supplementing the 27 interpretations previously reported on this page, have been issued by the Construction Code Authority, as follows:

28—Substantial Change in Plans

● It is impracticable in determining what constitutes a "substantial" change to fix a minimum percentage of change in the estimated cost of a project on which bids have been received justifying an invitation of new bids prior to the elapse of 90 days from the rejection of the original bids. It is the joint responsibility of the awarding authority and his Code authority to determine whether a "substantial" change in plans and specifications has been made.

29—Withdrawal of Bid

● The Code does not alter any existing legal right of a subcontractor to withdraw his bid from a general contractor and a bid depository after discovering an error in his price. A subcontractor, however, may not modify his bid after the time set for the receipt of his bid by the general contractor. The Code (Article VII, Section 9) provides that an awarding authority "shall not use any bid which is so unduly low as to indicate an error or mistake in estimating without first giving the bidder the opportunity of demonstrating, by cost sheets or other methods, the correctness of the bid that he has submitted."

30—Application under New Chapters

● This explanation involves the question of whether work undertaken prior to the approval of some additional divisional chapter of the code would be subject to the minimum wage rates for skilled labor specified in that divisional code chapter. Between March 2, 1934 (the date on which Chapter 1—the so-called Basic Code—became effective) and the effective date of any additional chapter the members of the particular division of the industry are bound only by the provisions of Chapter I and contracts entered into during this period or operations undertaken after the effective date in accordance with bona fide bids made not more than sixty days prior to the effective date of such approved chapter, but not prior to March 2, are not bound by the provisions of the particular chapter but only by the provisions of Chapter I.

31—Rejection of Bids

● Competitive bids submitted by subcontractors to a general contractor who bids to an awarding authority or owner are automatically rejected or cancelled if the owner determines to do the work in question directly with a subcontractor. The owner is free to obtain new prices subject, however, to the restrictions imposed by the code as to asking bids for substantially the same work previous to the elapse of 90 days from the date of such rejection and the provisions of divisional chapters restricting the alteration of bid price of members of such divisions.

32—Limitation on Bids

● Explanation was requested on what constitutes "an unreasonable number of bids" and "an unnecessary number of bids" as these phrases appear in Section 3(a) of Article VII of the Code. There is no authority under the Code to place a specific limitation on the number of bids to be invited. Whether an unreasonable number of bids has been invited depends upon the facts involved in the particular case.

On this point Section 3(a) of the Code reads: "Since it is recognized that the preparation of a bid is a service involving an expense to the bidder and that the inviting of bids is an economic waste, the awarding authority shall not invite an unnecessary number of bids."

Knott, in The Dallas Morning News

Too Many Palms to Grease

33—Receipt of Bids

● The question has been asked whether the modification of a subcontractor's bid delivered by telegram represents a modification physically in possession of the general contractor and therefore a legal bid within the meaning of Section 7 of Article VII. It is explained that such a condition has arisen in the case of an out-of-town subcontractor unable to modify his bid prior to the time set for receipt of bids except by telegram. A telegraphic bid as well as hand delivery is recognized as a legal bid or modification thereof, provided all other conditions for submitting bids are complied with.

Relief for One Construction Headache

● Road-building contractors will be saved a good deal of grief and many dollars of needless expense by a change in the special provisions governing highway construction under the National Industrial Recovery Act, recently announced by Thomas H. MacDonald, chief, U. S. Bureau of Public Roads, which restores the hiring of operators of heavy equipment to a logical basis. Under the old rules candidates from local relief lists claiming to be competent equipment operators had to be accepted and given an actual tryout on the job before being denied employment. Many of these self-styled operators knew little or nothing about the proper handling of the expensive machines to which they were assigned. In one notable case a Pennsylvania contractor tried out 27 men furnished by the local re-employment service before obtaining a competent power shovel operator. During this period production on the job was drastically curtailed and at the same time a sizable bill incurred for stripped gears, burned out clutches and other damaged parts.

Under the new ruling, however, contractors themselves are made the sole judges of the fitness of heavy equipment operators applying for work and they may hire or refuse to hire without permitting the candidates to handle the levers of their machines. Now, contractors may require prospective operators of heavy equipment applying for work, or referred by the local employment agency, "to furnish satisfactory evidence of competency to perform the work to which the employment relates before they are employed. Such evidence of competency may be a detailed statement of prior experience or recommendations from former employers who can be contacted for a statement of qualifications."

The effect of the new regulation is to relieve the contractor of the hazard of having expensive equipment wrecked and his job tied up by trying out new and often incompetent machine operators.

Day Labor *or* Industrial Recovery

WHETHER OR NOT government should go in for construction by day labor is, in these times, no mere question of a few jobs more or less for contractors. It cuts far deeper; it touches the heart of the whole recovery effort. With respect to the construction industry it might well be the difference between a help or a handicap to recovery.

Under normal conditions the question might fairly be considered on the economic merits of each case. If any community believes that it can do a job by day labor more satisfactorily than by contract the question is one of fact. It should be settled on the basis of fact — all the facts, comparable facts, honest facts. No investor, public or private, can reasonably be expected to employ an unsatisfactory procedure merely because of custom or to make work for any special group. But the existence of a construction industry is evidence that over many years it has, by its performance, justified its existence as an industry.

This makes it necessary, under present conditions, to take some additional factors into account. The volume of construction to be done is none too great and most of it is public enterprise made possible by the public credit. Many of these works have been undertaken as a measure of national recovery. They are designed to nourish the industrial organism through a period of famine, to help construction and its dependent industries to provide employment for their workers and their capital.

Obviously if this effort is to succeed it must be administered with this objective constantly in view. It cannot be perverted to meet the needs of individual relief, to indulge ambitious department heads or to pioneer new areas of governmental endeavor.

THE WAY TO INDUSTRIAL RECOVERY IS TO HELP THE INDUSTRIES TO RECOVER, NOT TO UNDERMINE AND SUPPLANT THEM.

And right here we must remember that an industry is something more than a lot of people engaged in a certain type of work. A major essential of any industry is its going value: its fabric and organization, coordination of specialized groups, recognized channels of responsibility, natural procedure and established practice.

All this is quite obvious in the case of most manufacturing industries; it is most obvious in the case of an army. A mere aggregation of a million men is not an army; it is but a mob, formless, ineffective and unstable until it is organized. It cannot function as an army until each individual knows his place, is allotted his special duty and trained to perform it, until by experience and practice he learns to know and work with his fellows, until all have been assembled into appropriate units and the units habituated to do their parts naturally, competently and confidently. Until we provide a structure and establish a practice, our mob of individuals, however qualified each of them may be, is not an army.

So with an industry. Government might assemble all the workers of the construction crafts, put tools into their hands and put them to work but it would not thereby sustain the construction industry. By so doing it we might create a certain amount of temporary employment and accomplish a certain amount of work but it would not be fulfilling the purpose of the National Industrial Recovery Act.

For in that process it would tear down something that has cost this country years of time, millions of capital and the lives of generations of able men to build. It would undermine the structure of the industry, the framework that maintains it and holds it together. It would paralyze the very functions upon which this sorely harassed and vital industry must depend to make the most of the nourishment that has been made available through the public works program. It would be feeding the industry with one hand and throttling it with the other.

Fortunately all this is clear to the many public officials who have consistently followed the normal practice of awarding their work by contract and who thereby are making a genuine contribution towards industrial recovery. But their example should be kept before those others who mistakenly assume that the public interest is better served by handling through day labor work that might be turned over to the organized construction industry. The volume of available construction is meager enough. In the interest of general recovery no public construction project should be withheld from the construction industry except for the weightiest of reasons.

The American people built an organized construction industry because they needed it; they are going to need it again. Our task is to see it through the present emergency.

Willard Chevalier

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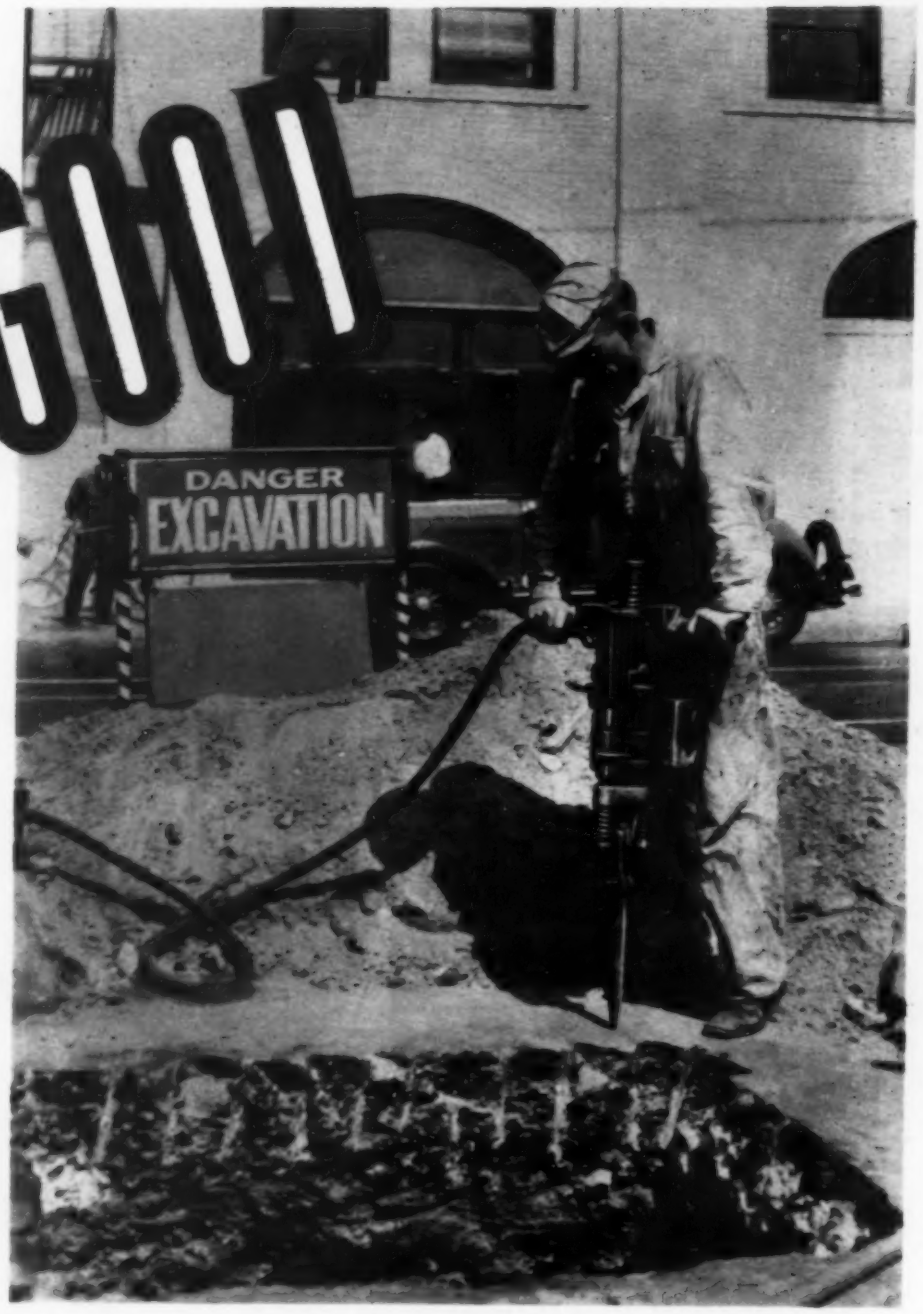

says *W. M. Henderson of Los Angeles Gas & Electric Corporation*

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The BARCO GASoline HAMMER is a portable, self-powered unit, built for fast, economical service in the field of concrete breaking, back-fill tamping, shallow drilling, sheet driving, digging, etc.

Writing in the American Gas Association Monthly of May, 1934, W. M. Henderson of the Los Angeles Gas & Electric Corporation, has this to say concerning the actual performance of this amazingly useful and practical tool:

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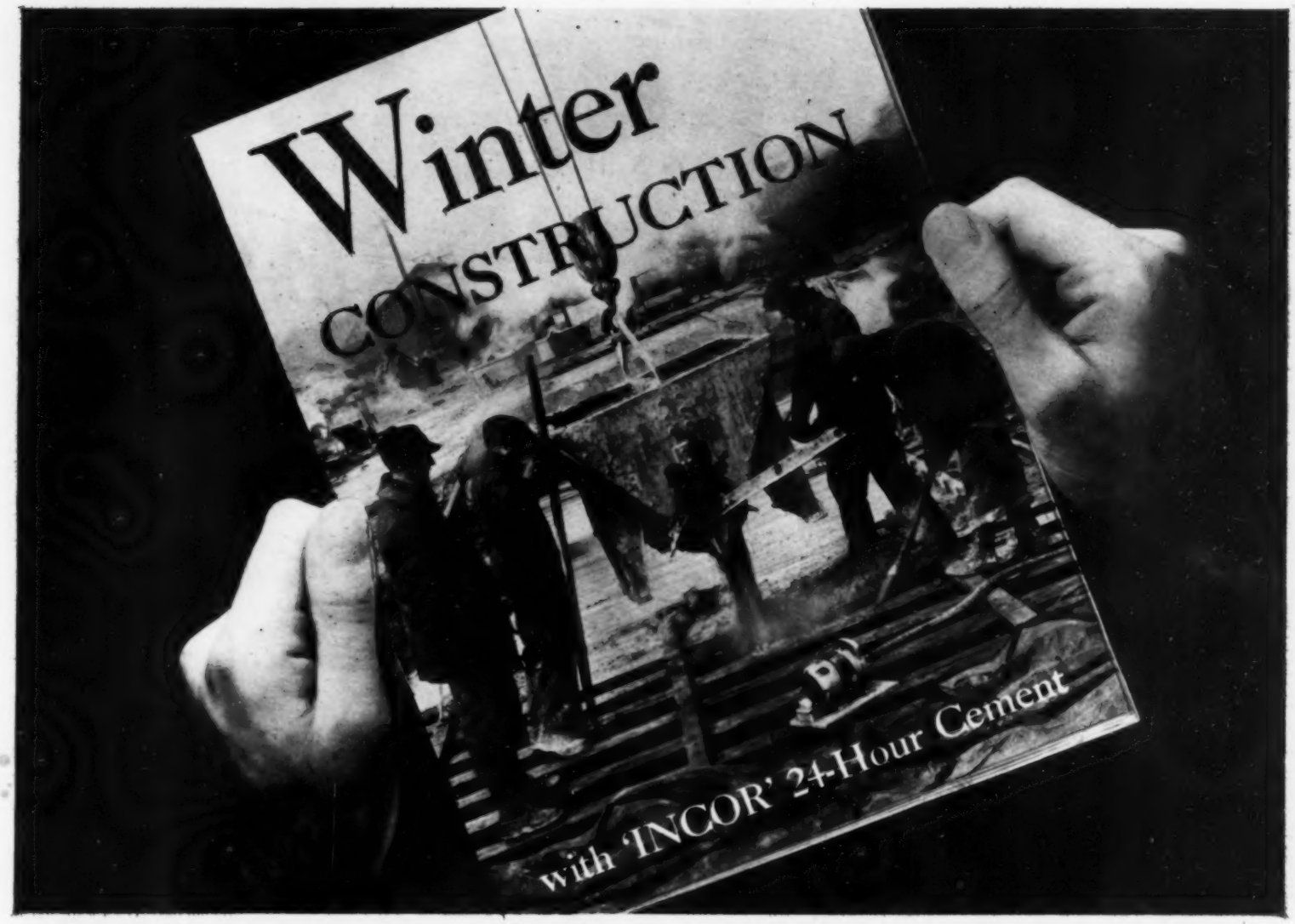

Cold-Weather Building on Summer Schedules

YEAR-AROUND BUILDING has been talked about for a generation. The fact that this idea, though widely accepted, is not acted on more generally, suggests it may be more a matter of expense than of custom.

It costs money to heat concrete, supply heat protection, and space out construction schedules. Perhaps that is why attempts to 'educate' the construction industries have made so little progress. We may be wrong, but doesn't it seem logical that if you can reduce by 60% or 70% the cost of winter heating and protection; re-use forms in 2 or 3 days, instead of 2 or 3 weeks; minimize the hazards of sudden cold waves, and maintain summer schedules in cold weather —that more headway can be made in the next five years than in the past 25, toward a 12-month building year? The pocketbook is a lot more convincing than the text-book!

Read how 'Incor' Cement makes these savings possible—in a new, illustrated book entitled "Winter Construction." It isn't a lot of sales-promotion copy — it's full of helpful, down-to-earth suggestions. Write for a copy today.

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Ready for the concrete.
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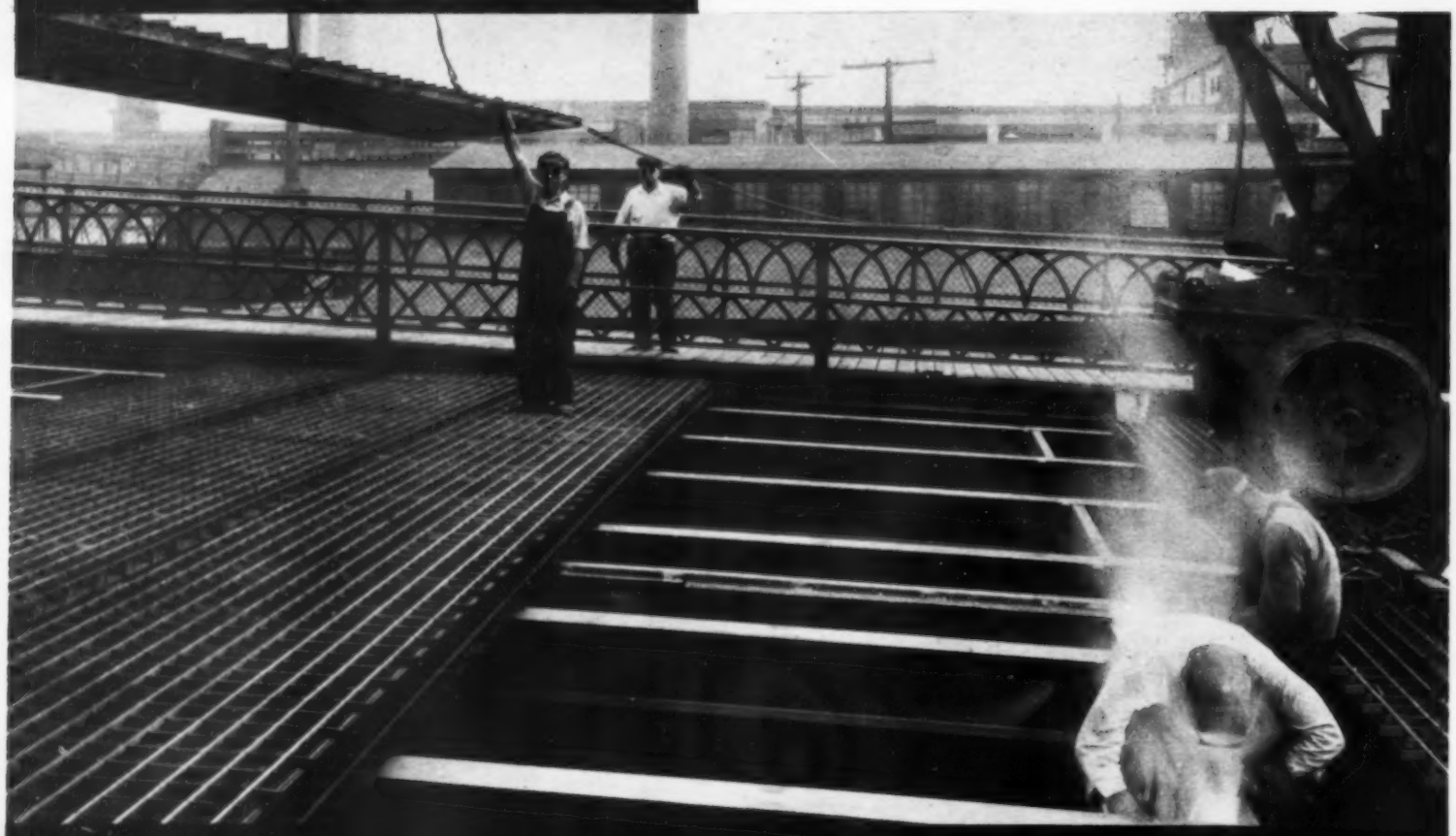
TOMORROW'S BRIDGE *To-day!*



Installing standard I-Beam-Lok units. Note heavy truck crane riding directly on unfilled units.

I·BEAM·LOK *Armored*

BRIDGE ROADWAY SLABS AND HEAVY DUTY FLOORS

Over the railroad tracks form strips were omitted. Wood forms were placed ¾" below I-Beam-Lok units to provide smooth concrete under-surface.

25,000 square feet of I-Beam-Lok—the first installation of this new, light, strong bridge flooring—was successfully used in re-flooring the East Grand Boulevard Viaduct over the Grand Trunk Railway lines, Detroit. The work was divided into two contracts. The city portion included two sloping approach ramps 40′ wide, and the railroad portion over the tracks, two level roadways totaling 40′ in width. • I-Beam-Lok is particularly suitable for such reflooring jobs. In many cases no modification in the structure is necessary. In new work, the reduced dead load of I-Beam-Lok permits substantial savings in the cost of the entire structure. • Send for our new booklet, or better still, let our engineers discuss this truly important development with you.

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WILLIAM E. LENNANE, *Contractor, railroad portion.*

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BLACK TOP PAVER

the cutter bar strike-off for Accuracy

Better hang on to them-

with the right set-up, these two cards will take the pot!

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Knowing when to discard and when to "play 'em" is the secret of success in poker — and business, too. A Quarry Man would hang on to these two cards because so much profit is tied up with "Easier Removal" and "Giant Blasts". Cordeau-Bickford Detonating Fuse has made the giant blast practical and popular in quarry work. If your set-up permits one big shot in place of a lot of little ones, you too can use Cordeau to good advantage.

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Ensign-Bickford Safety Fuse is available in a number of standardized brands, each carefully made for a particular set of conditions. The use of Safety Fuse simplifies blasting technique.

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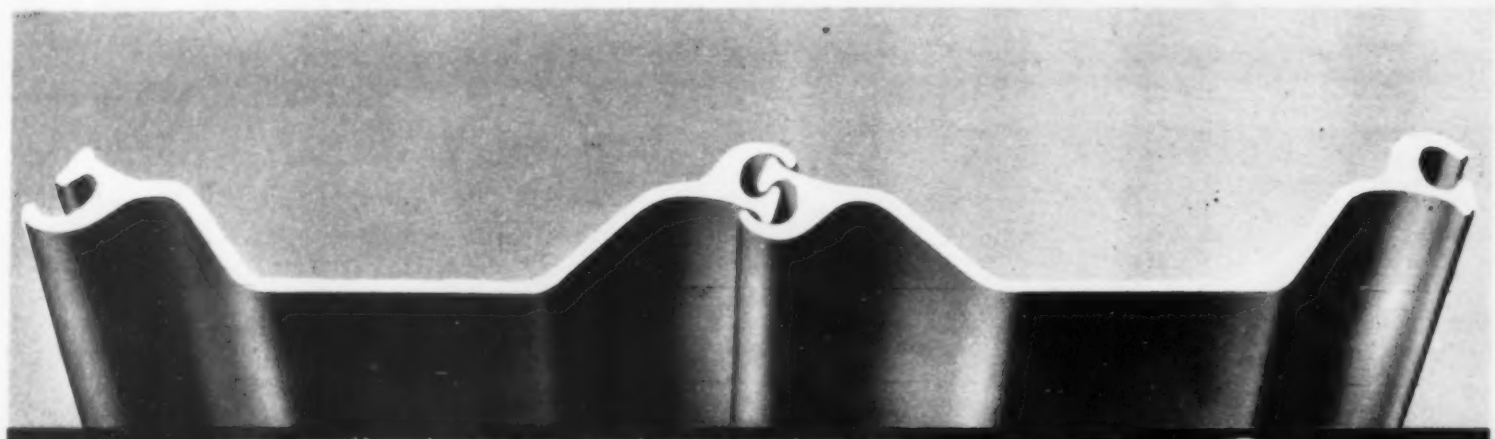

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The heavy-duty piling section *for construction work*

THIS cofferdam for Pier No. 4 of the Fore River Bridge between Quincy and Weymouth, Mass., is 88 ft. long by 42 ft. wide. It was built of Bethlehem Steel Sheet Piling Section AP8, 15 in. wide, weighing 31 lbs. per sq. ft., in lengths of 48 and 55 ft.

Before unwatering, excavation was made to 38 ft. below high-tide level. A concrete footing 11 ft. thick was placed under water with a bottom-dump bucket. The cofferdam was then unwatered down to the top of footing, 27 ft. below high tide. The leakage through the piling was negligible. The steel sheet piling along the river face will be driven down as a permanent protection to the pier.

Bethlehem Section AP8 is designed particularly for cofferdam construction such as this. It is a rugged section, capable of withstanding exceptionally rough usage in driving and pulling. It has heavy, strong interlocks, which afford ample surface for contact with the driving hammer.

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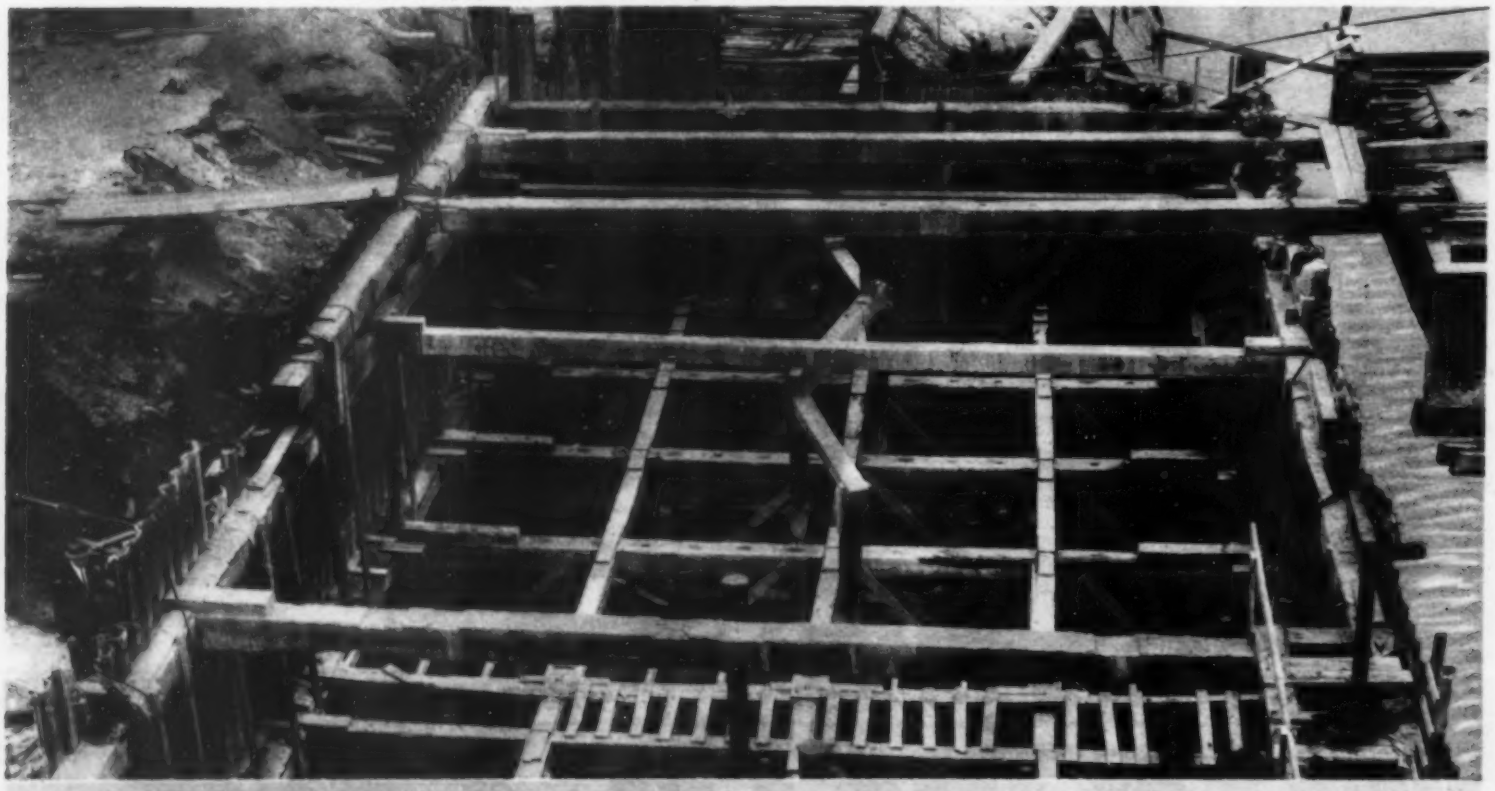

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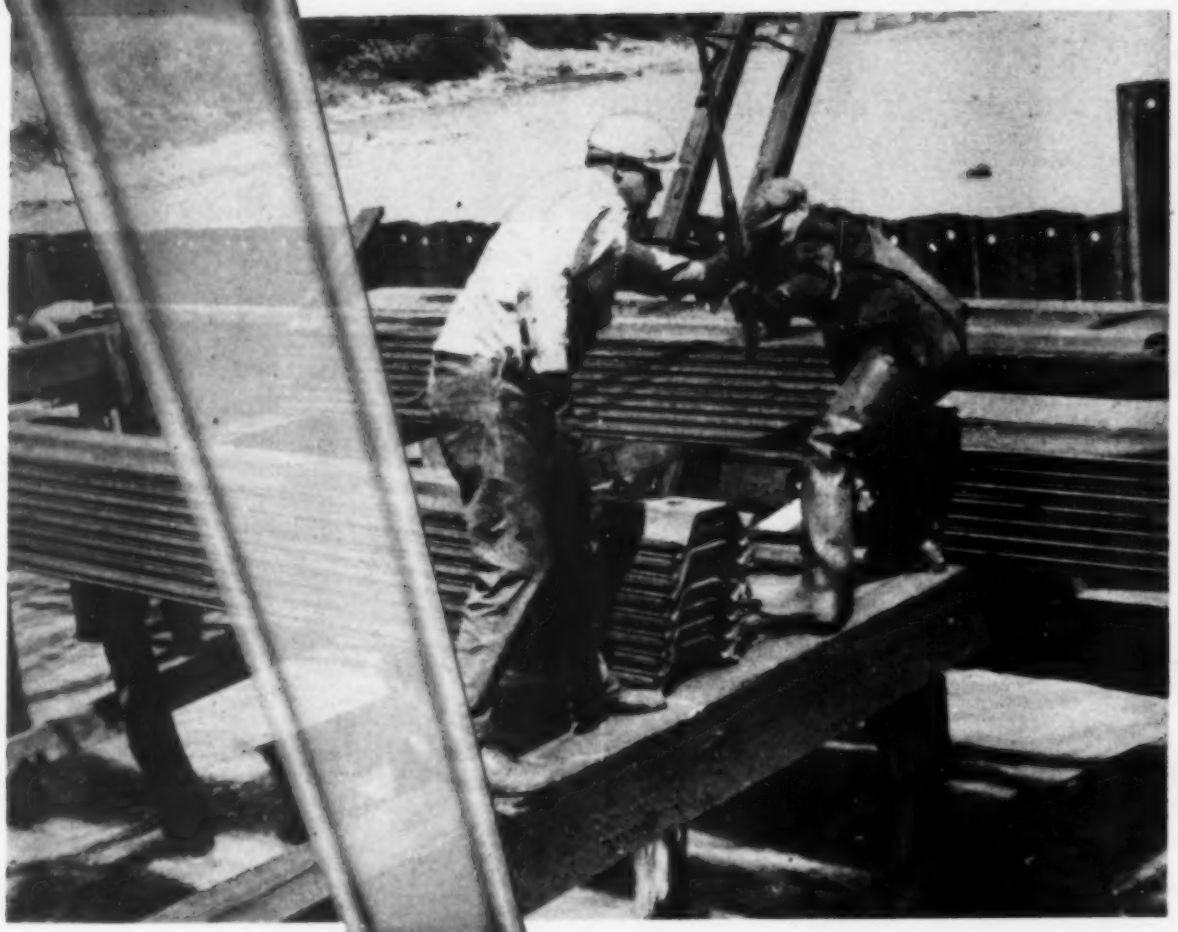

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AVOID SIDEWALL "FAILURE ZONE" TROUBLES WITH NEW TRIPLE PROTECTED TRUCK TIRES

You know what it means when a tire goes bad out on the job. Men, trucks and equipment stand idle. Many more dollars than the cost of a tire repair are lost! Why not prevent those unnecessary failures before they happen? Read the story of an amazing new tire invention below.

LOADS TOO HEAVY?—Hundreds of truckers carrying dirt loads report that their tires fail in the sidewall. What's the reason? Sometimes it's because the tires are overloaded. Often it's just because the tires can't take it! But Goodrich has a tire that can! It's the new Triple Protected Silvertown—the tire that positively checks 80% of these premature failures.

NO LONGER A DREAM—Goodrich knew and admitted that the sidewall—the "Failure Zone"—was the weak spot in truck tire construction. Everybody's tires failed there. So Goodrich engineers went to work. Now the tire with the sidewall as strong and husky as the tread is no longer a dream! You can get it today. It's the new Silvertown with three-way protection right where you need it most.

PROVE IT ON CONCRETE MIXERS—You can prove the value of Triple Protection on concrete mixers. Install a set of tires on a mixer or a truck where you have had trouble with sidewall failures. You'll get the surprise of your life. You'll get months of extra service even on the toughest jobs. Yet you pay not one cent extra for Triple Protection.

FREE! Trucker's Handbook

Write today for your free copy of "The Truck Operator's Handbook," full of valuable truck tire data that you can put to immediate use. No obligation. Address Department T-148, The B. F. Goodrich Company, Akron, Ohio.

LOOK AT ALL THREE—Before you buy another truck tire consider all three of these new exclusive Goodrich features. Can you afford a tire without them?

1 PLYFLEX—a *new*, tough, sturdy rubber material with greater resistance to stretch. A layer of Plyflex in the sidewall distributes stresses and strains—prevents ply separation—checks local weakness.

2 PLY-LOCK—the new Goodrich way of *locking* the plies about the bead. Anchoring them in place. Positive protection against the short plies tearing loose above the bead.

3 100% FULL-FLOATING CORD—Each cord is surrounded by rubber. With ordinary cross-woven fabric, when the cords touch each other, they rub—get hot—break. In Silvertowns, there are no cross cords. No friction.

Goodrich *Triple Protected* Silvertowns
FOR TRUCKS AND BUSES

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PREFORMED WIRE ROPE

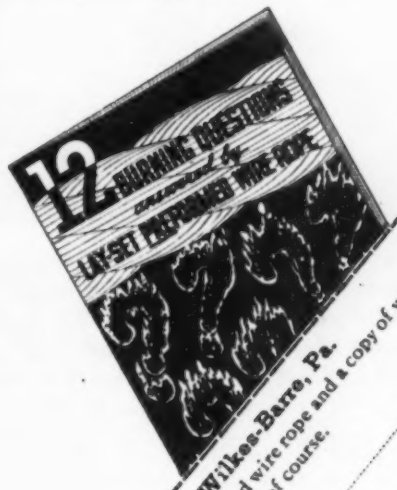
AND MAKE IT SELL ITSELF!

● The coupon below will bring you a sample length of LAY-SET Preformed wire rope. Send for that sample today and make it sell itself—in the privacy of your office, at your convenience.

When you receive your sample, take it apart, then put it together again, as illustrated. By this simple test LAY-SET will prove how the preforming process—

... does away with all internal stress ... resists kinking ... makes every wire carry its full load ... cuts the time costs of replacement ... makes broken wires lie flat ... eliminates the necessity for seizing ... makes LAY-SET last longer.

LAY-SET Preformed wire rope has revolutionized all old ideas of wire rope service and economy. Send for a sample of LAY-SET and a copy of the new booklet "12 Burning Questions." Sign and return the coupon right now.



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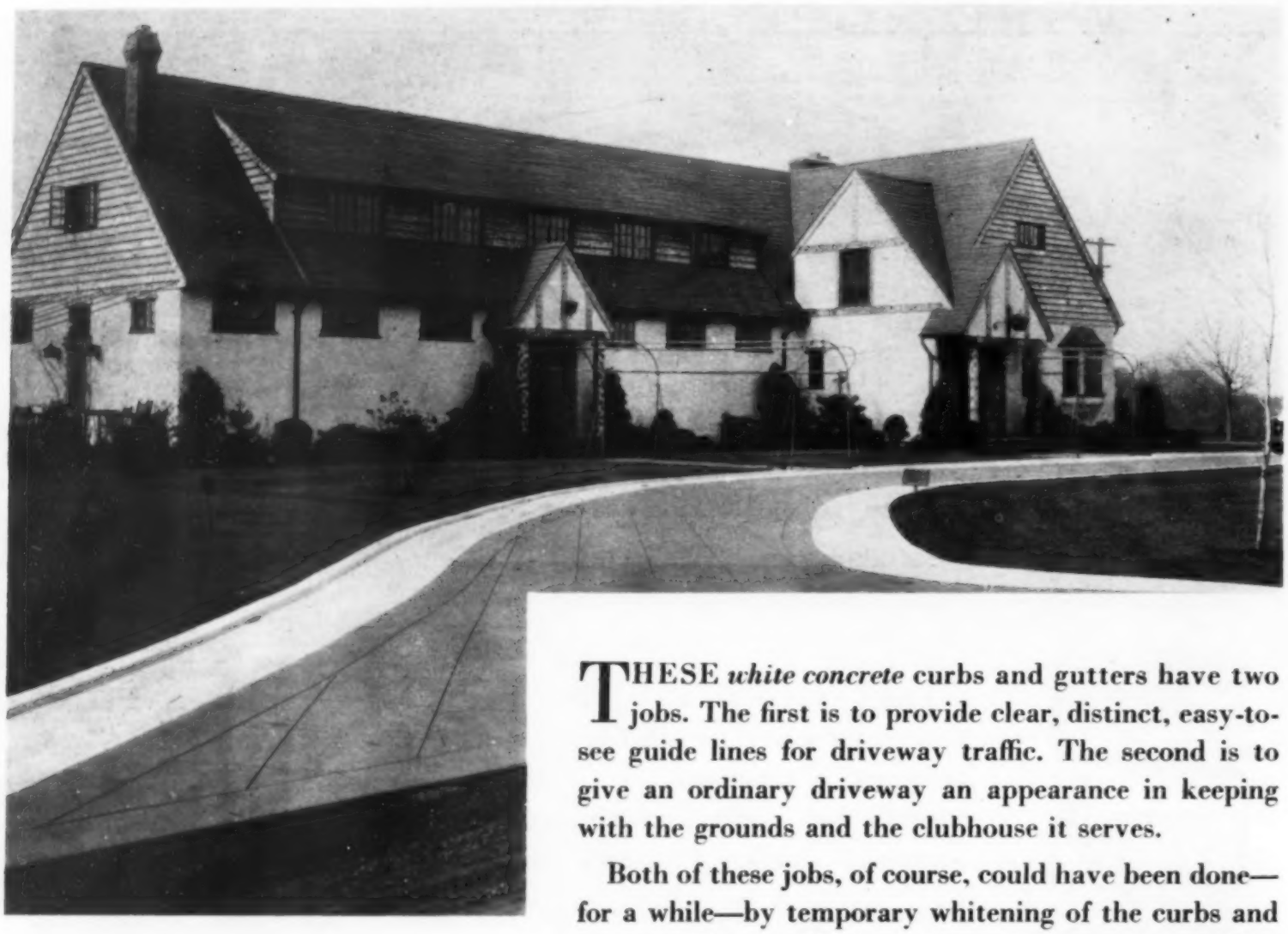
White Concrete Curbs
FOR APPEARANCE
. . . as well as Economy



White concrete curbs and gutters built with Atlas White portland cement at Oceanside Golf Links, Oceanside, L. I., N. Y. Paul Jagow, architect. Wilfred Stewart, general contractor. Both of Lynbrook, L. I., N. Y. (Note—Atlas White was also used for the attractive, durable stucco on the clubhouse.)

THESE *white concrete* curbs and gutters have two jobs. The first is to provide clear, distinct, easy-to-see guide lines for driveway traffic. The second is to give an ordinary driveway an appearance in keeping with the grounds and the clubhouse it serves.

Both of these jobs, of course, could have been done—for a while—by temporary whitening of the curbs and gutters. That would have been cheaper—for a while. But because *final* cost was figured and because *continuous* good appearance and service were required, *permanent* white concrete was used.

These curbs and gutters will never need replacement. There will be *no* maintenance costs. They will *stay white*, spic and span, always. For complete information, write Universal Atlas Cement Co., *Subsidiary of United States Steel Corporation*, 208 South LaSalle Street, Chicago.

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ATLAS WHITE MARKERS AND CURBS

Made with Atlas White Portland Cement—Plain or Waterproofed

Construction Methods

ROBERT K. TOMLIN, Editor

Established 1919—McGraw-Hill Publishing Company, Inc.

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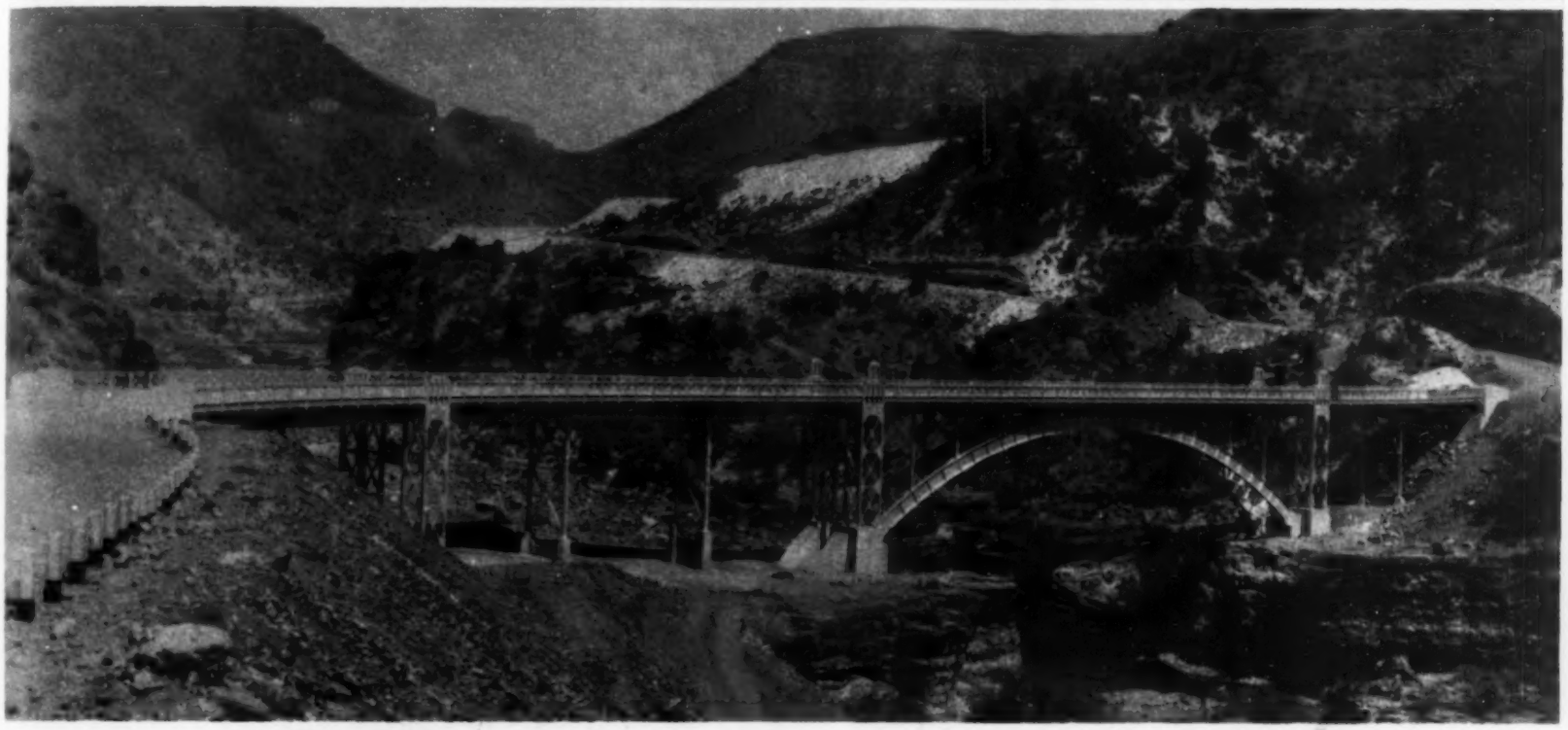


SALT RIVER BRIDGE has main arch span and seven approach spans, 455 ft. long overall, protected by aluminum paint.

Arizona Highway Crosses Salt River on New

Steel Arch Span

AS PART of the heaviest construction it has ever undertaken, characterized as a mountain road from beginning to end, the Arizona Highway Department, on an 84-mile section of U. S. Highway No. 60 crossing public domain, forest lands and Indian reservations between Globe, in Gila County, and Showlow, in Navajo County, has replaced an ancient foot bridge across the Salt River with a new steel arch span and seven approach spans, with an overall length of 455 ft. The structure carries a concrete deck which is notable for the fact that its design involves five different curves, both vertical and horizontal.

For the footings along the walls of the canyon almost all of the foundation rock was exposed and the only work required consisted of leveling off the surface and removing areas of doubtful quality. The main river span is 148 ft.

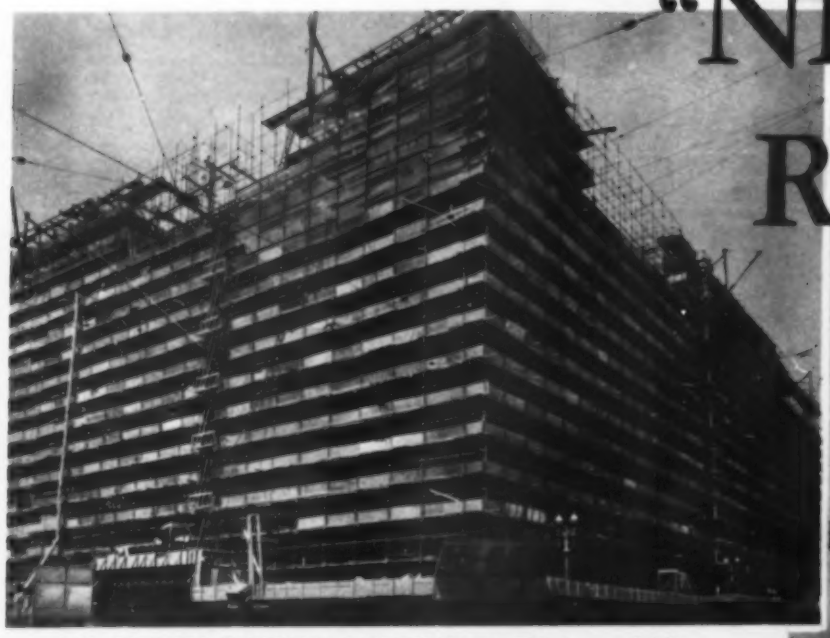
CANTILEVER ERECTION with aid of cableway is employed by contractor on arch span across Salt River.

long and was built by the Lee Moor Construction Co., using a method of cantilever erection, with the aid of a cableway spanning the site, as illustrated in the photograph at the bottom of the page. The completed structure is coated with aluminum paint.

The bridge and a half-mile of adjacent highway included in the contract employed a force of 43 men for a period of 30 weeks, working in shifts of 5 hr. for 6 days a week. After working 120 hr. the men were temporarily suspended for a similar length of time in order to spread employment. The cost of the bridge was $58,050 and of the adjoining half-mile section of highway, $41,950.

Under the direction of T. S. O'Connell, state highway engineer, the work on U. S. Highway No. 60 was in charge of R. C. Perkins, district engineer, and A. F. Rath, resident engineer.

This Month's "NEWS REEL"



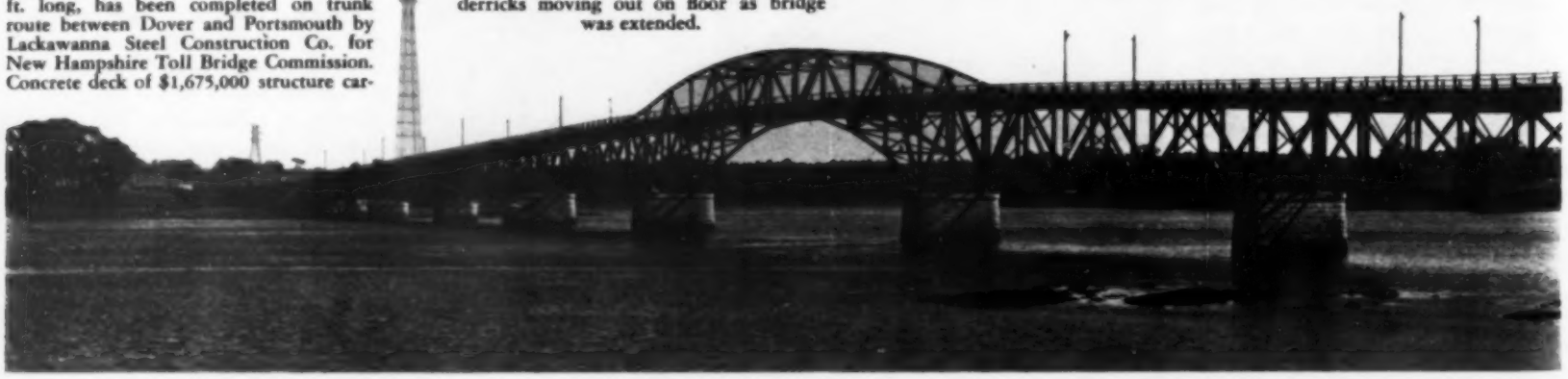
LOS ANGELES BUILDING MODERNIZED. Tubular scaffolding, carrying 2 mi. of solid planked runways 6 ft. wide, erected around department store structure of J. W. Robinson Co., aids Richards-Neustadt Construction Co., of Los Angeles, in replacing old exterior brick wall with reinforced Gunite shell and glazed tile facing, as major part of extensive reconstruction and improvement program.

TRIBOROUGH BRIDGE TOWER, to support one end of 1,380-ft. suspension span across East River, New York City, is erected to roadway level by Taylor-Fichter Steel Construction Co. View shows construction at Borough of Queens end of bridge. Height of completed tower will be 270 ft. above pier base. Tower legs are 98 ft. apart center to center. Project is financed by grant of $7,200,000 and loan of $37,000,000 from P.W.A.

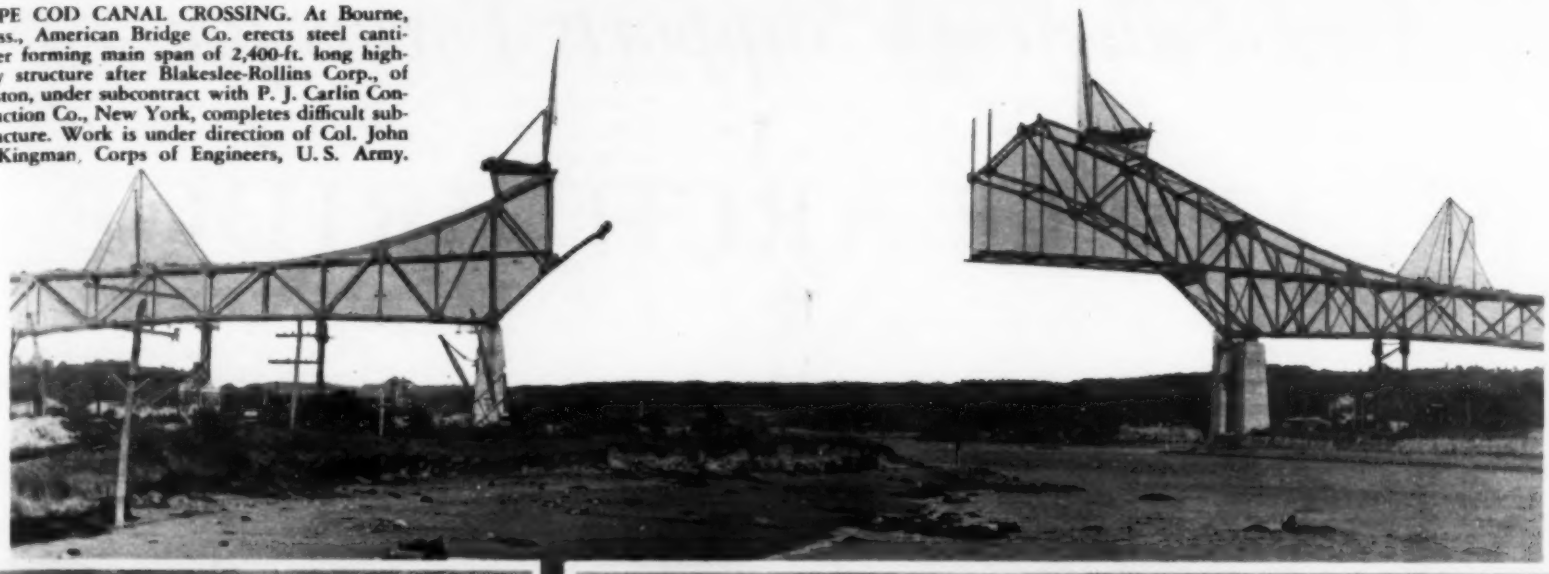
BONNEVILLE DAM navigation and power project on Columbia River between Oregon and Washington is scene of construction activity as fleets of heavy trucks remove material excavated by power shovels, first step in $31,250,000 program, under direction of Corps of Engineers, U. S. Army. Overflow gravity-type spillway dam of concrete in main river channel will be 1,100 ft. long, 75 ft. high and 180 ft. wide, surmounted by eighteen 50x50-ft. vertical-lift steel gates between tall piers and abutment walls.

FIRST P.W.A. HOUSING PROGRAM, comprising 50 small homes at Alta Vista, Va., has been completed. *(Left to right)* V. L. Lewis, contractor, delivers keys of houses to R. D. Brannon, architect, while H. M. Lane, president of Alta Vista Housing Corporation, studies release on houses given him by Walter A. Dunnigan, acting supervising engineer for the P.W.A.

NEW HAMPSHIRE HIGHWAY LINK. Little Bay high-level steel bridge, 1,528 ft. long, has been completed on trunk route between Dover and Portsmouth by Lackawanna Steel Construction Co. for New Hampshire Toll Bridge Commission. Concrete deck of $1,675,000 structure carries 24-ft. roadway. Main channel span was erected by cantilever method using pair of derricks moving out on floor as bridge was extended.

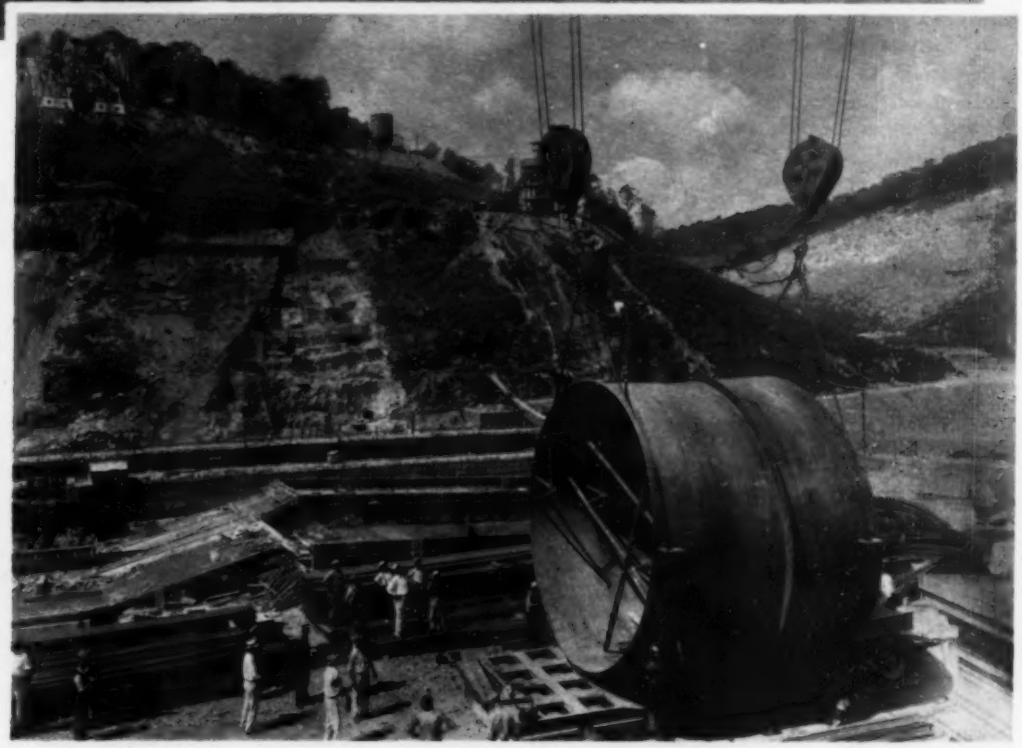


CAPE COD CANAL CROSSING. At Bourne, Mass., American Bridge Co. erects steel cantilever forming main span of 2,400-ft. long highway structure after Blakeslee-Rollins Corp., of Boston, under subcontract with P. J. Carlin Construction Co., New York, completes difficult substructure. Work is under direction of Col. John J. Kingman, Corps of Engineers, U. S. Army.



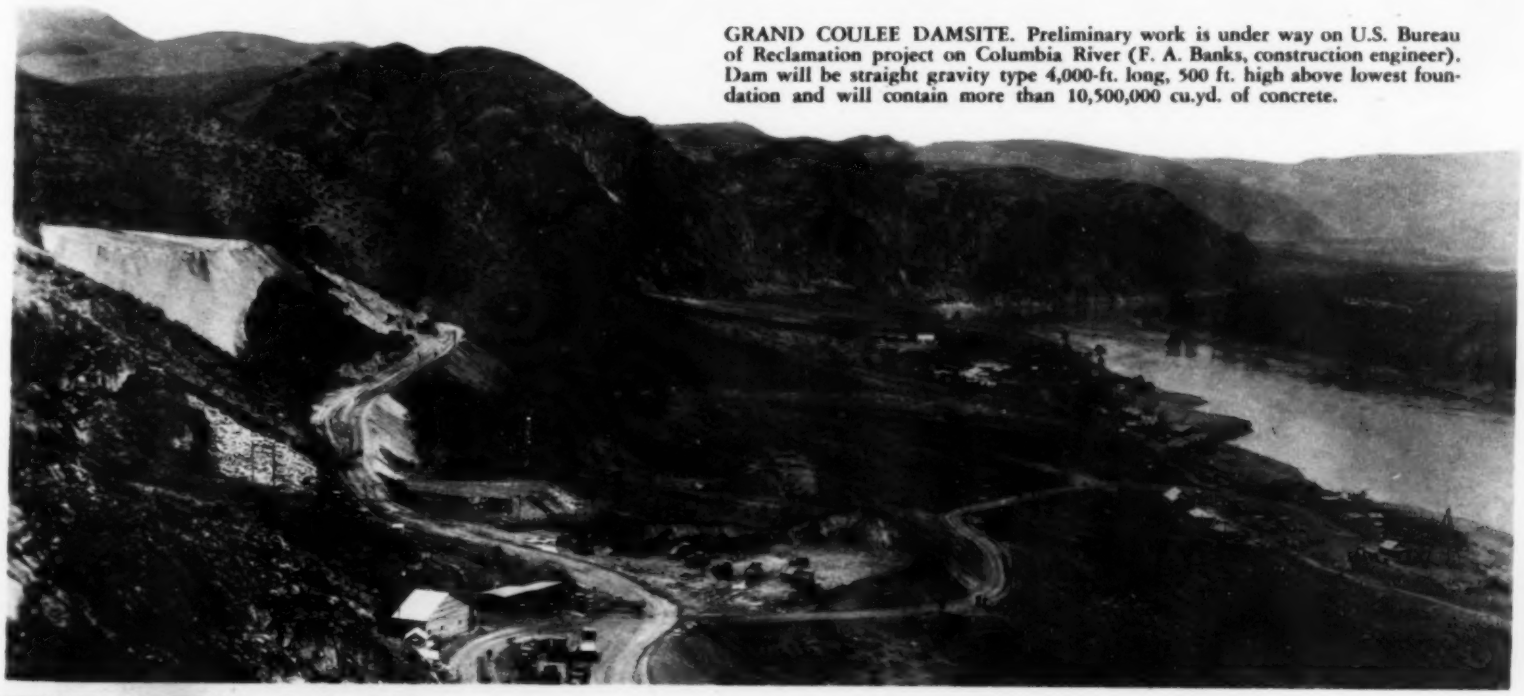
U. S. Bureau of Reclamation Photo.

BOULDER DAM PENSTOCK. First sections of huge 30-ft. diameter steel pipe are installed on vertical curve below intake tower in Nevada penstock header tunnels. View is looking upward from base of tunnel showing men ascending ladder.



FIRST SECTION of penstock pipe is lowered to place by cableway at Norris Dam, being built across Clinch River by Tennessee Valley Authority. There will be two of these pipes, each 20-ft. in diameter and several hundred feet long, serving the turbines of the power plant.

GRAND COULEE DAMSITE. Preliminary work is under way on U.S. Bureau of Reclamation project on Columbia River (F. A. Banks, construction engineer). Dam will be straight gravity type 4,000-ft. long, 500 ft. high above lowest foundation and will contain more than 10,500,000 cu.yd. of concrete.



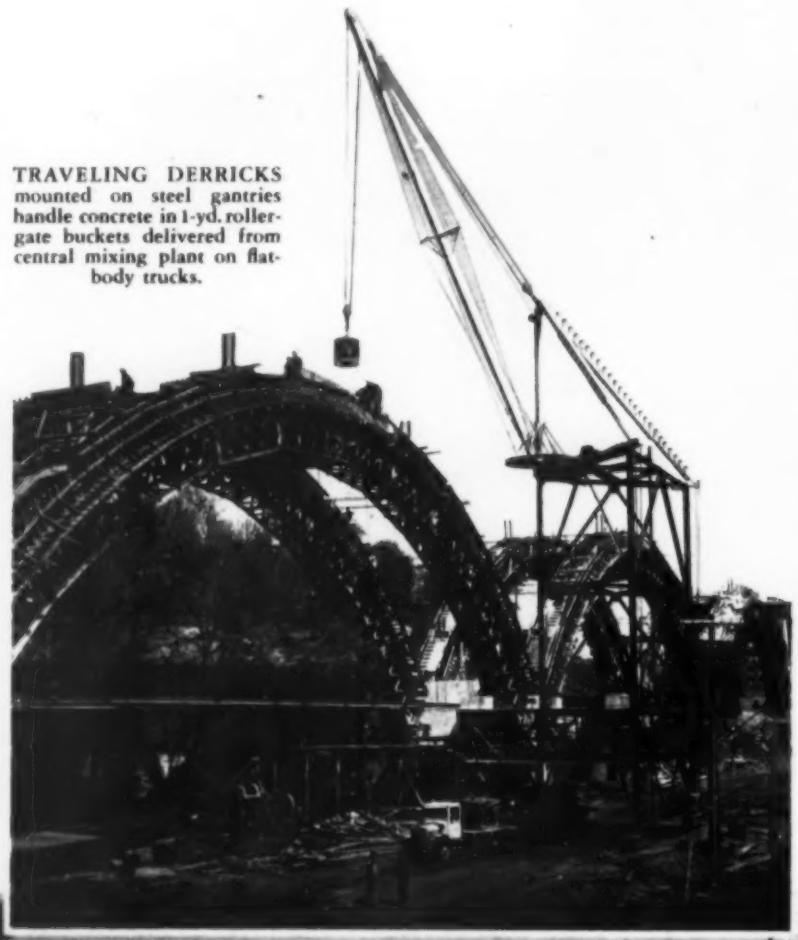
Steel Falsework Supports Forms for

MULTIPLE-ARCH BRIDGE

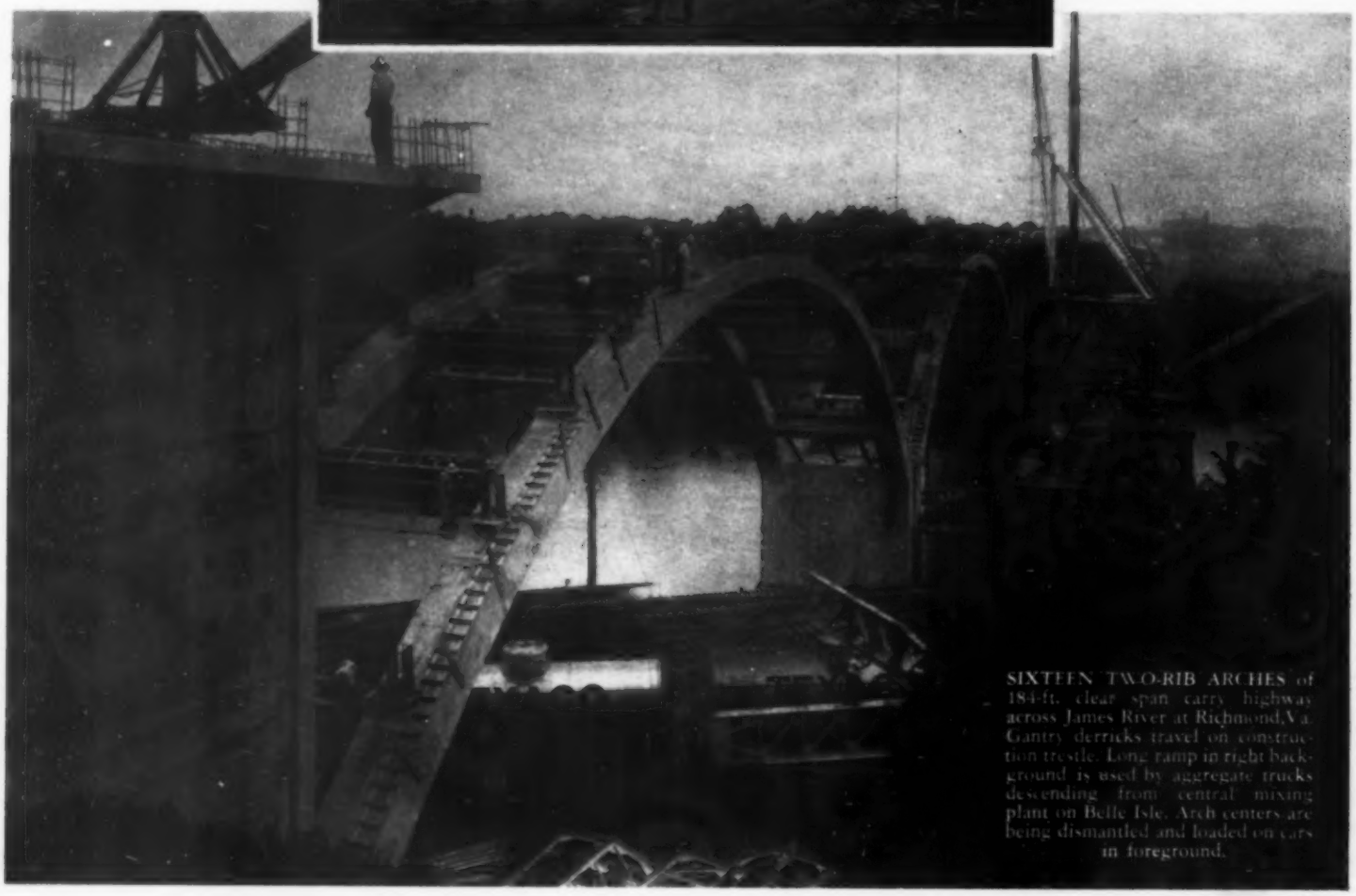
PORTABLE structural steel bents, erected on the arch ribs, support the forms for slender spandrel columns and deck on a 3,300-ft. multiple-arch bridge across the James River, in Richmond, Va., which the S. M. Siesel Co., of Milwaukee, Wis., is building for the Richmond Bridge Corp. under the direction of Allen J. Saville, Inc., of Richmond, engineer for the bridge corporation. Concrete is mixed at a central plant on an island in the river and is delivered in buckets by trucks to mobile gantry derricks traveling on a construction trestle. At the central mixing plant, all concrete ingredients are delivered by light motor trucks which climb a steep ramp to discharge into elevated bins. Forms are built in panels for repeated use, and all exposed concrete surfaces are cast against plywood forms.

Bridge Design—Unusual features of the bridge, which was designed by A. C. Janni, of New York City, consultant on bridge work for Allen J. Saville, Inc., produced certain problems and complications in formwork. The design developed by Mr. Janni eliminates all rockers or sliding plates (except roadway plates) and relies upon flexible, heavily reinforced columns to allow for expansion and contraction in the supported slab. To cross the two river channels and Belle Isle, the island which divides them at the site, the design employs sixteen two-rib, reinforced-concrete arches of 184-ft. clear span. Typical spans are 197 ft. 4 in. long, c. to c. of piers. In cross-section, the ribs are 5 x 5 ft. at the springing line, and 5 ft. wide by 3½ ft. deep (measured radially) at the crown.

All piers are founded on rock at maximum depths of about 20 ft. below high water. Two of the piers, pier 4 and pier 12, were designed as abutment piers for purposes of construction. Typical piers are about 16x32 ft. in plan and the two abutment piers are about 32x32 ft. Above the water line all piers are cellular in construction. At each pier a short section of deck slab between the decks of the two adjacent spans is supported by individual columns, separate from the end columns of the arch spans. Expansion joints between the slabs are bridged by steel



TRAVELING DERRICKS mounted on steel gantries handle concrete in 1-yd. roller-gate buckets delivered from central mixing plant on flat-body trucks.



SIXTEEN TWO-RIB ARCHES of 184-ft. clear span carry highway across James River at Richmond, Va. Gantry derricks travel on construction trestle. Long ramp in right background is used by aggregate trucks descending from central mixing plant on Belle Isle. Arch centers are being dismantled and loaded on cars in foreground.

roadway plates resting on steel angles cast in the concrete. The short connecting slabs are about 4 ft. long on the typical piers and about 18 ft. long on the abutment piers.

A 40-ft. roadway and two 4-ft. sidewalks are supported by the two lines of spandrel columns, spaced 26 ft., c. to c. Along the lines of the spandrel columns the deck slab is supported by reinforced-concrete girders running longitudinally and resting on the tops of the columns. Between the two rows of columns the deck slab is of T-beam construction, with the T-beams running in two directions. At their intersections, these T-beams are supported by short posts rising from transverse cap beams of the concrete bents. The transverse beams serve both as bracing struts and as load-carrying members. Reinforced-concrete brackets extending out from the bents carry the cantilever portion of the roadway and the sidewalk. A study of the photographs will help to clarify features of this design.

A short and simple approach, including one concrete girder span, connects the multiple-arch bridge with the roadway on high ground at the south end. At the north end a longer approach crosses railroad tracks and a canal. This approach has two side ramps connecting the bridge roadway with a street on a lower level. Reinforced-concrete girder construction was utilized for all spans of this approach, and pier foundations of the supporting bents were carried to rock, except in the case of the five bents on the south (lower) side of the canal, where concrete pile foundations were substituted to eliminate any rock blasting which might have caused leaks in the south wall of the canal.

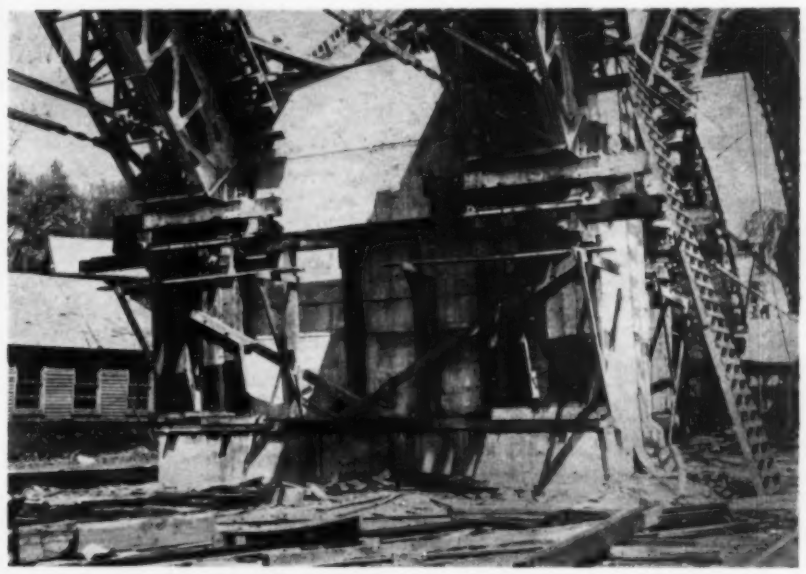
STEEL CENTERS *(above)* support arch ribs during construction. Two timber carriages under this arch are used in moving individual centers intact from one set-up to next, one carriage being placed under each end of centering.

ARCH RIB FORMS resting on steel centers are constructed of plywood. Stubs of transverse struts (partially inclosed by forms) will be cast with key blocks of arch rib.

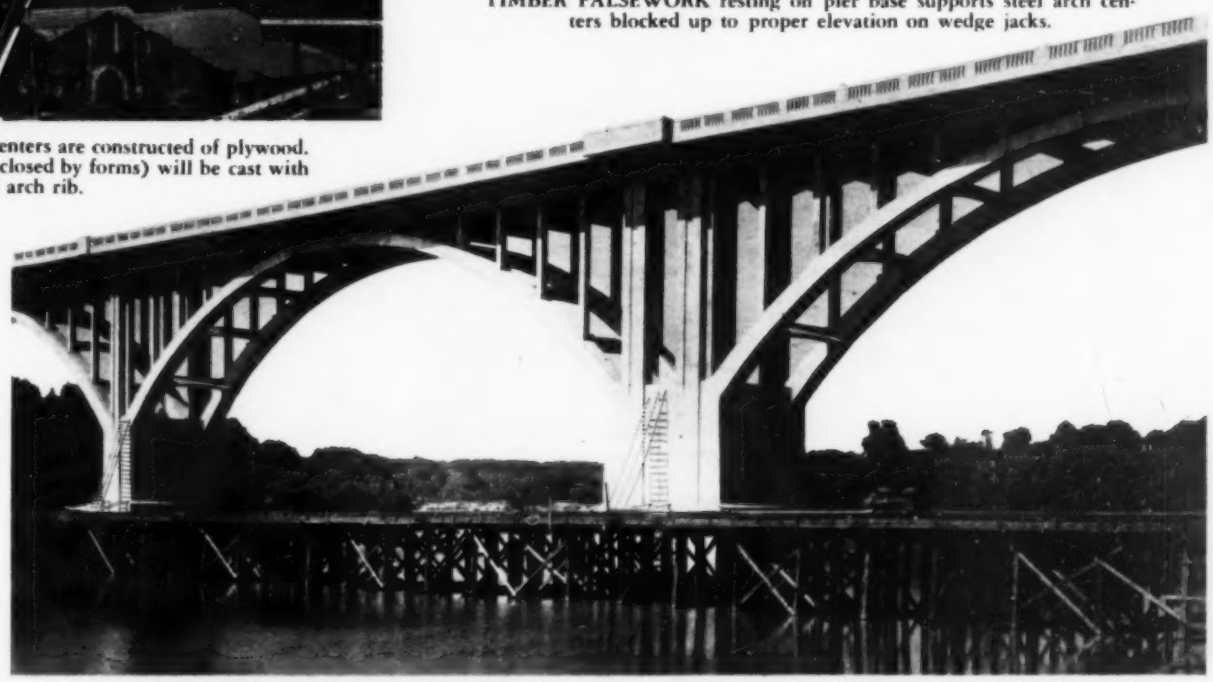
Plant Layout—Starting at the south end of the multiple-arch section of the structure, the first span crosses the tracks of the Southern Railway, the next two arches span the south channel of the river, seven arches traverse Belle Isle and the remaining six spans cross the north channel to the bank of the stream. An antiquated through-truss steel highway bridge, with a roadway wide enough for only one line of traffic, connects the north bank with Belle Isle. Railway access to the island is provided by a spur crossing on a bridge to the main line on the south shore of the river.

Belle Isle presented the logical location for a central mixing plant to produce concrete for the entire 3,300-ft. structure, with the exception of the inaccessible north approach, which could be constructed to better advantage by paving mixers served by batch trucks. The bridge requires about 30,000 yd. of concrete. For greater flexibility in distributing concrete the contractor determined to use motor trucks to haul loaded concrete buckets from the mixing plant. The trucks were to travel over a construction trestle, erected on the downstream side of the bridge, delivering the buckets to mobile gantry derricks which would operate on the same trestle. Before designing these last items of the construction plant the contractor built scale models of the bridge, construction trestle, and gantry derricks to determine what relative heights of temporary bridge and gantry derrick towers would produce the greatest construction economies. Partly as a result of these studies it was decided to build the construction trestle on the same grade as Belle Isle, thus eliminating all trestle construction for about 1,400 ft. across the island and effecting a corresponding saving.

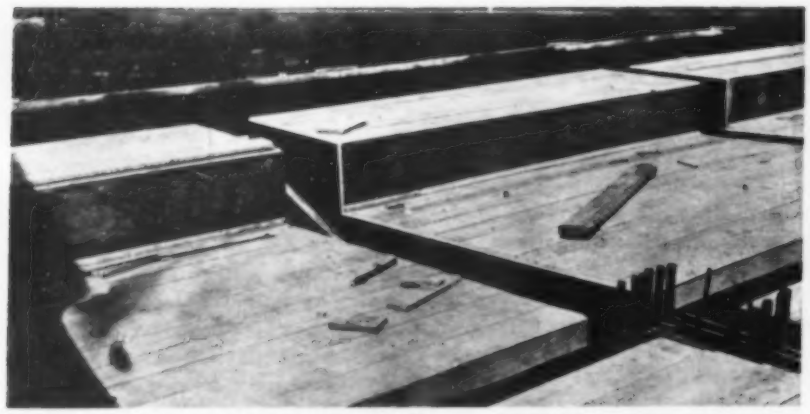
At the central mixing plant, by elevating the overhead bins to a sufficient height above the ground and building timber ramps on a steep grade to permit delivery of materials from dump trucks into these bins, the contractor obtains economical gravity flow of concrete ingredients from the dump-trucks



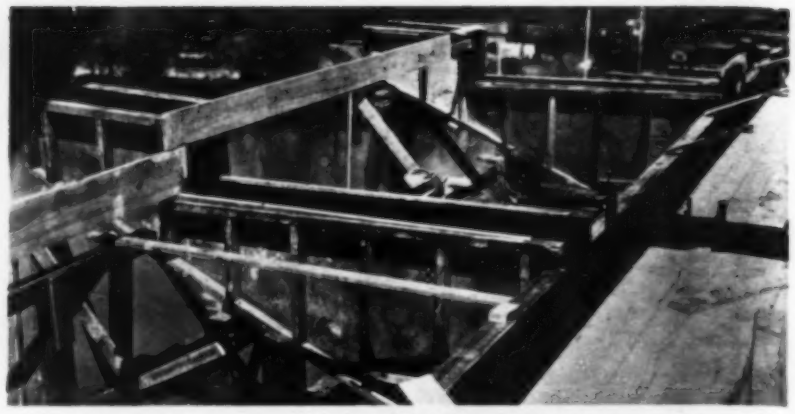
TIMBER FALSEWORK resting on pier base supports steel arch centers blocked up to proper elevation on wedge jacks.



GRACEFUL DESIGN employing reinforced concrete exclusively characterizes multiple-arch bridge across James River. Abutment pier in foreground supports 18-ft. roadway span on independent columns (which appear as pilasters above main mass of pier) entirely separate from spandrel columns of arch structure. Similar design supports shorter independent roadway slab above typical pier in background. Construction trestle parallels bridge.



PLYWOOD FORMS are specified for all exposed concrete surfaces such as fascia girders and roadway curbs. Resultant concrete surface eliminates mechanical finishing.



PREFABRICATED PLYWOOD FORM PANELS for cantilever roadway and sidewalk beams and for deck girders facilitate erection and give many repeated uses.

through the bins and weighing hoppers to the 2-yd. mixer, which, in its turn, discharges the concrete directly into 1-yd. roller-gate buckets on the trucks. Going up to the top of the mixing plant, loaded material trucks climb a 13-per cent timber ramp, and in leaving they descend a 20-per cent ramp. Eight-cylinder light trucks, carrying 4 yd. of sand or gravel, climb the 13-per cent ramp in high gear without difficulty. Bulk cement is delivered in hopper bottom box cars over the railway spur to an existing tipple on the island, whence it is transported to the mixing plant by 4-yd. trucks.

The temporary timber construction trestle is anchored securely against floods in the river. In the north channel at least three posts at the upstream end of each bent are doweled to the rock bed of the river by 1¼-in-diam. steel dowels. In the south channel the posts of the construction bridge are driven into the irregular rock bottom of the river, and the bents are anchored to steel bars set in concrete in drilled holes upstream. Both sections of the construction bridge were tied to the concrete piers by cables as rapidly as the piers were completed. These precautions saved the construction trestle during high water which rose within 4 ft. of the deck.

On a 28-ft. gage track laid on the two construction bridges and across Belle Isle operate three mobile gantry tower derricks, designed by experienced crane builders, the Lakeside Bridge & Steel Co., of Milwaukee, Wis. Each of the towers is 60 ft. high above the rail and all of them provide a gantry opening 10 ft. high above the roadway. A tower is moved along its tracks by hooking on with a hauling line attached to a truck. On each tower is mounted a stiff-leg derrick (either steel or wood) with an 85-ft. boom. The travelers are designed to lift a 5-ton load on a flat boom. Two of the derricks are driven by steam hoist engines, one a 7x10-in. and the other a 6½x10-in., and the third is operated by a 50-hp. gasoline hoist engine. It has been the experience of the contractor on this work that the steam hoists are faster and that they are to be preferred for various other uses to which they can be adapted, such as supplying steam for the removal of ice.

STRUCTURAL STEEL FALSEWORK carried by arch ribs supports spandrel-column and deck forms during construction.

AT CROWN OF ARCH, six transverse steel falsework girders are suspended from arch ribs by steel angle hangers. Nearer haunch, steel bents rest on arch ribs.

BETWEEN CROWN AND HAUNCH, structural bents are anchored to special seats provided on arch ribs. These bents serve to plumb slender column forms.

Pier Foundations—Pier footings were carried down into solid rock inside box-type cofferdams filled with puddled earth. The outside line of sheeting around each cofferdam consisted of splined Wakefield piling, each pile being made up of three 2-in. planks nailed together in such a way as to form a tongue at one edge and a groove at the other. A single line of 2-in. wooden planks formed the inner wall of the cofferdam. Four crawler cranes aided the excavation and concreting of the piers.

Construction Procedure—Eight Blaw-Knox steel centers support the arch ribs during construction. The original design of the multiple-arch river crossing contemplated the use of this number of centers. In accordance with this idea, piers 4 and 12 had been made abutment piers. These piers would have been sufficient to take care of all unbalanced arch thrust during construction, provided the contractor had been willing to cast single ribs in a continuous line across the intermediate spans. As an alternate, in case the contractor wished to complete both ribs of four spans before moving to the next four arches, the engineers permitted pier 8 to be converted into an abutment pier to take arch thrust from the south by buttressing it on the north side. A different alternative was proposed by the contractor and accepted by the engineers.

Because the four piers on the north side of Belle Isle were the first ones to be completed, the S. M. Siesel Co. desired to cast first the ribs between piers 8 and 12. To carry out this plan it was necessary to convert pier 8 into an abutment pier to resist arch thrust from the north. The contractor proposed, and the engineers agreed, that this strengthening of the center pier be carried out by placing a fill of solid concrete between the designed pier and the solid rock wall of the excavation on the south side of the pier. By casting the eight ribs of four spans simultaneously it was possible to begin promptly construction of the large section of deck supported by the four arches.

After these arches had been completed the centers were struck and moved to positions between piers 12 and 16. The next move of the arch centering was to the four spans between Piers 4 and 8, and, as the final operation of arch-rib construction, the centers are being utilized on the remaining spans between the south abutment and pier 4.

Form Construction — Among the most remarkable features of the contractor's equipment are the portable structural frames designed to support the beam and deck forms and to hold the slender column forms plumb dur-

ing construction. To provide a bearing for these steel bents, the steps on the arch ribs designed to furnish seats for the column forms are extended and furnished with anchor bolts to secure the steel columns at their bases. After the steel columns have been plumbed, the forms for the concrete columns are erected and tied to the steel by battens. As indicated by one of the photographs, the transverse beams of the structural steel falsework bents support the bridge deck for its full width of 49 ft. Near the crown of the arch, six transverse falsework beams are suspended by steel angle hangers from the arch ribs.

Forms were made up in panels for repeated use, and forms for all exposed concrete surfaces were built with plywood, as specified. The contractor purchased 100,000 sq.ft. of plywood for this use. Plywood forms have given about eight uses on piers and from five to six uses on arch ribs, columns, beams and girders. Some of the plywood forms have been used twelve times or more. These forms produced such a smooth, dense concrete surface that the engineers requested that mechanical finishing be omitted, although this finishing had been included in the contract specifications.

One feature of the design simplifies construction of cross-ties (or struts) between the arch ribs and of four transverse beams at the crown of the arch. At the locations of all these transverse members stubs to support falsework are cast monolithically with the ribs.

Casting Arch Ribs—Mobility of the concrete-placing equipment greatly facilitates all concreting operations and proves particularly advantageous in casting the arch ribs. Either one or two of the gantry derricks can place concrete in the arch ribs of a single span, depending upon the speed with which the work has to be performed. In the first stage of concreting an arch rib, concrete is placed in seven blocks, or segments, separated by key sections. In placing this concrete, great care is taken to load symmetrically, as an unbalanced load would cause distortion of the centering and possibly obstruct removal of the centers after the ribs have been completed.

In the first seven blocks, a mixture approximating 1:2:4 proportions is used. After these blocks have cured for 7 days, to allow full shrinkage to take place, the contractor casts the key blocks, using for these sections a richer mixture of about 1:1¾:3½ proportions. Test cylinders, filled with concrete taken out of the key sections, are broken at the end of 7 days. If the breaking tests give a compressive strength of 3,500 lb. per square inch, the centers are struck at the end of another 7 days—a total of 14 days after the casting of the keys.

Moving Arch Centers—Two built-up timber carriages, equipped with wheel trucks on 28-ft. gage to fit the gantry track, are used to move the steel arch centers, as indicated by several of the photographs. The arch centers are shifted on and off these carriages on greased steel plates. Wedge jacks raise and lower the arch centers when they are being installed and struck. When in position to support the arch forms, the centers rest at both ends on timber falsework built up from the pier footings.

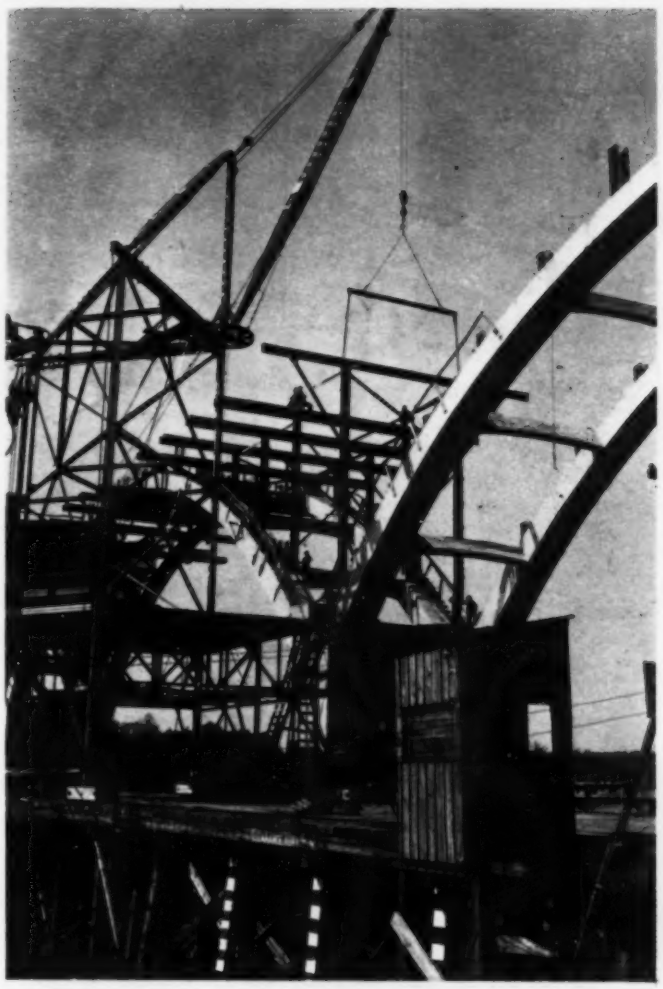
In one day of 10 hr., the carriages can be brought into proper position on the 28-ft. gage track, the necessary falsework and rigging installed, and an arch center removed, transported and set up in final location for the casting of another arch rib. The carriages are entirely satisfactory, except for the fact that they block all other operations on the construction trestle while they are in use. If the contractor ever uses similar equipment on other projects, the carriages will be designed as gantries to permit truck traffic to pass through them while they are on the construction bridge.

Progress and Personnel—A contract for construction of the James River Bridge was awarded to the S. M. Siesel Co., in May, 1933. The bridge is now open to traffic.

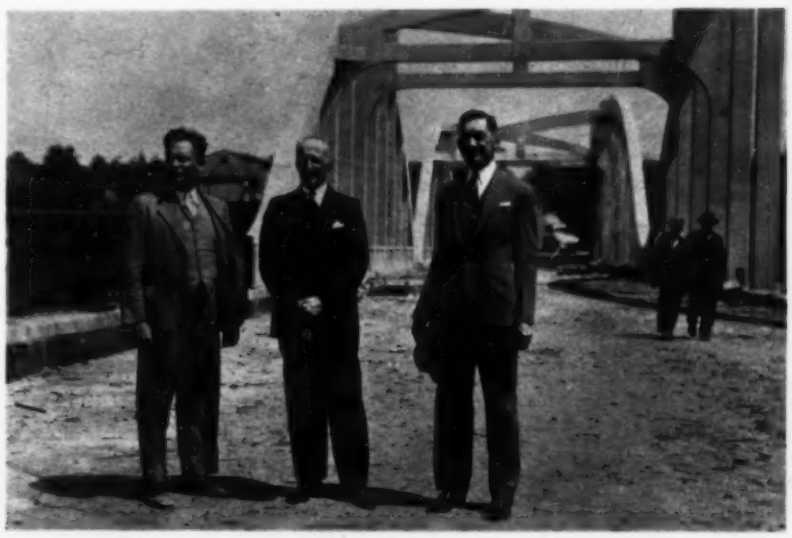
For Allen J. Saville, Inc., engineer for the Richmond Bridge Corporation, R. S. Hummell, vice-president, is in active charge of design and construction. A. C. Janni, of New York City, is consultant on design.

The Richmond Bridge Corp. was created to build five reinforced-concrete bridges and to recondition a steel viaduct in the city. All of these structures are to be operated as toll bridges. The work is financed by a loan of $1,700,000 from the Reconstruction Finance Corporation. F. H. Roberts, supervising engineer, represents the interests of the Reconstruction Finance Corporation.

For the S. M. Siesel Co., the contractor, E. D. Steinhagen is general superintendent and V. F. Quinlan was assistant superintendent until about May 1, 1934, when he was transferred to Washington, D. C., to take charge of a project in the latter city.



STRUCTURAL STEEL FALSEWORK BENT is erected intact by traveling derrick. Seats on arch ribs designed for spandrel column forms are extended and provided with anchor bolts to furnish bases for steel columns.



IN CHARGE OF ENTIRE PROGRAM of bridge construction and reconstruction in Richmond. *(Left to right)* R. S. Hummell, vice-president of Allen J. Saville, Inc., engineer for Richmond Bridge Corp.; Alfredo C. Janni, design engineer; and F. H. Roberts, engineer for Reconstruction Finance Corp.

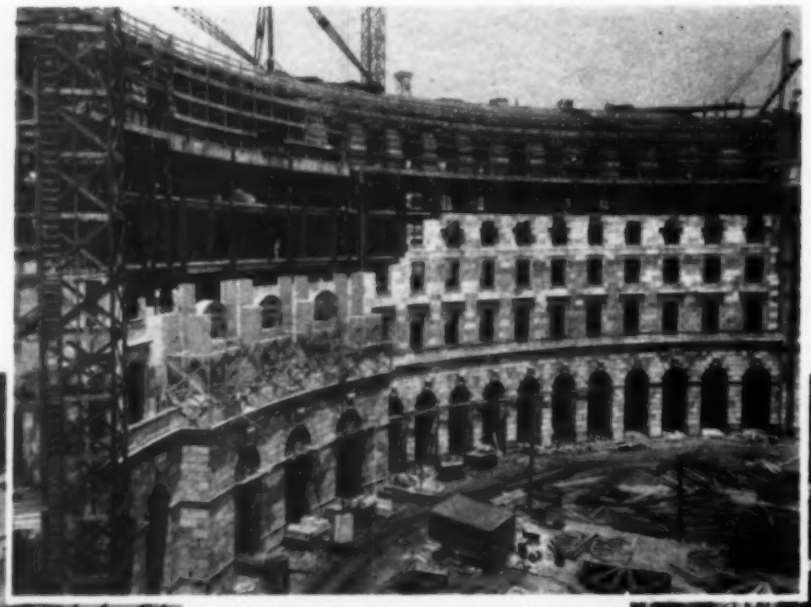
E. D. STEINHAGEN, general superintendent for S. M. Siesel Co., directs construction of bridge.

ON JOB AT BRIDGE. R. S. Hummel, of Allen J. Saville, Inc., and A. W. Johns, resident engineer.

Hand-Operated Equipment

Places 200,000 Cu. Ft. of Building Stone

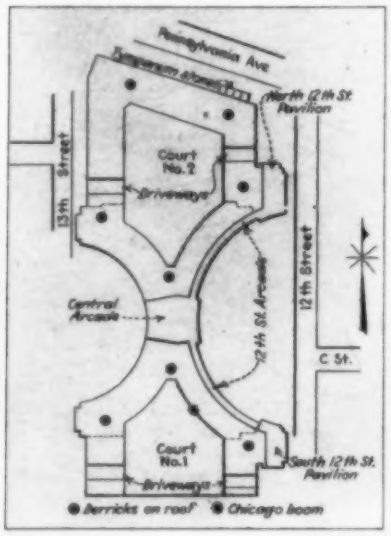
SPECIAL light, manually operated equipment was used for handling, distributing and setting more than one-third of the total quantity of 575,000 cu.ft. of stone which the S. M. Siesel Co., of Milwaukee, erected for the new Post Office Department building, Washington, D. C., under subcontract with McCloskey & Co., of Philadelphia, general contractors. The stone erector's principal hoisting equipment comprised seven steel stiff-leg derricks

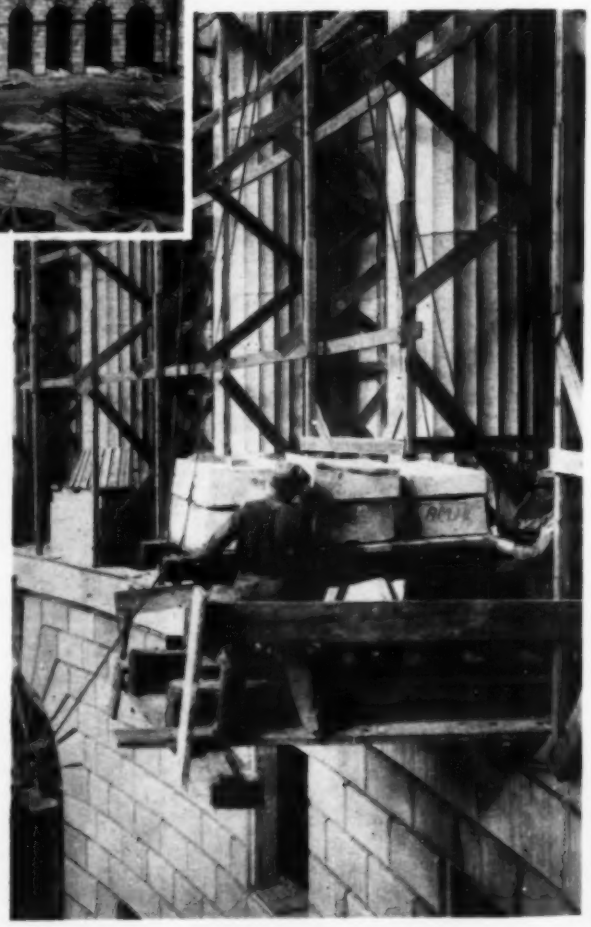


Design of Building—The Post Office Department building is a steel-frame structure eight stories high, of irregular plan, with principal dimensions about 750 ft. by 320 ft. Curved courts cut into the east and west sides of the building and form a comparatively narrow central section which connects north and south portions built around light courts. Exterior walls of the building are faced with limestone backed up by brick. Limestone also is used in the

SKIPLOAD OF SMALL STONES is removed from truck by derrick slings at building site.

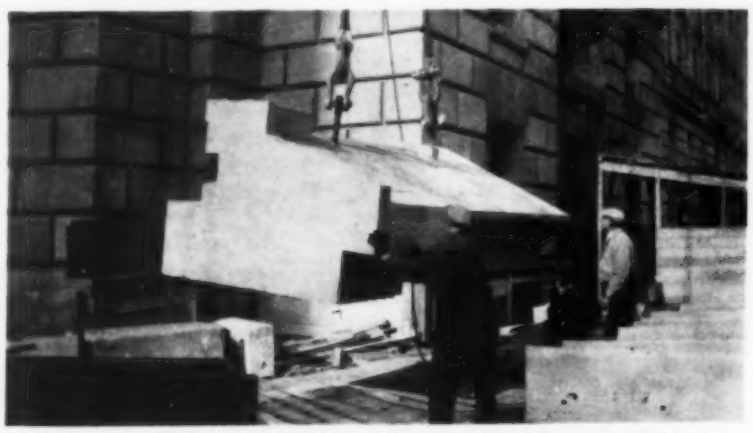
EXTERIOR WALL around curved court on 12th St. side of Post Office Department Building, shown by general plan *(below)*, is covered with limestone facing relieved by marble columns and trim. Locations of stiff-leg derricks on roof and of Chicago boom in south court are marked on plan.





AT UPPER FLOOR, skipload of small stones is lowered on to projecting roller conveyor.

(one of which was used in two locations), and one Chicago boom. These heavy hoisting units lifted and placed the large exterior stones and delivered skip-loads of the lighter pieces from motor trucks to outrigger roller conveyors at the upper floors. The lighter stones, weighing up to 2 tons each, were placed on wood platform skips at the railroad yard. They remained on the skips until transferred at the receiving conveyors to smaller units for distribution on the floors



25-TON PEDIMENT KNEELER, one of heaviest stones in building, is lifted by hoisting bridle attached to two box lewises.

walls and ceilings of arched driveways and arcades on the ground floor of the building. Columns and stone trim on the east side of the structure are principally of marble; similar decorative features on the west side are limestone. Steps and areaways are paved with granite. The design calls for almost 500,000 cu.ft. of limestone and somewhat less than 40,000 cu. ft. each of marble and granite.

Stone Handling Methods — Large stones were hoisted from the trucks and

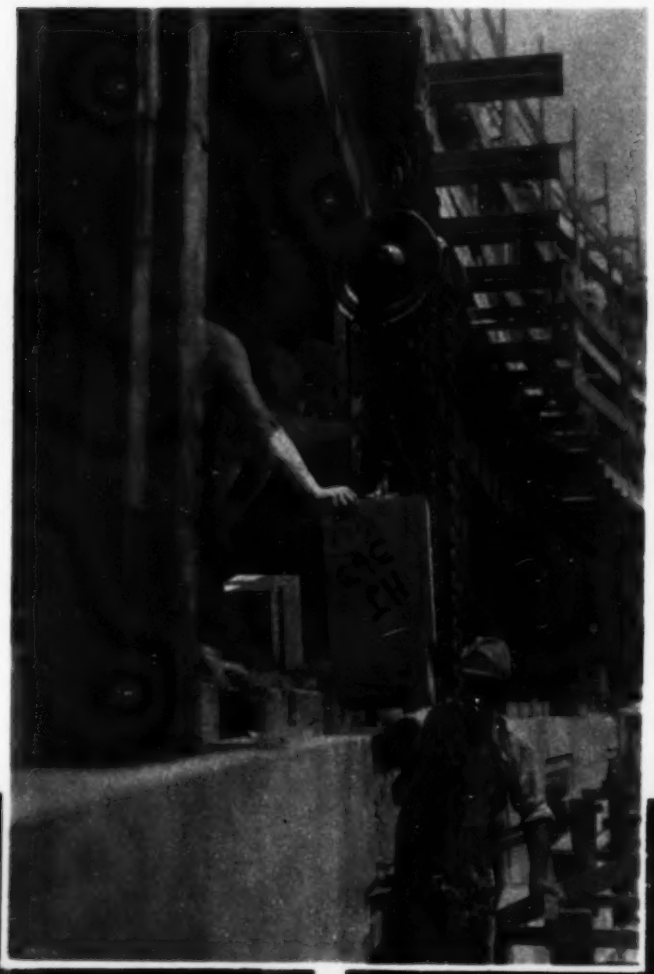
WOOD CENTERS are erected to support stone ceiling of 12th St. arcade during construction.

TELESCOPIC CHICAGO BOOM attached to interior column above second floor level sets ceiling stone in arcade below. Hand winch fastened to column in background operates hoisting falls.

ARCHED STONE CEILING of 12th St. arcade has many intersecting curves which demand special stone shapes and precise erection.

set by the steel derricks in the conventional way, but the lighter stones were handled by methods which in several respects marked an improvement over standard practice. The contractor used about 1,000 wood skip platforms 4x6½ ft. in size to transport the smaller pieces from the railroad yard to the building. These skips were loaded and placed on trucks at the yard. In the case of heavier pieces, only one stone was placed on a skip. At the building, the steel derricks hoisted the loaded skips from the trucks to projecting roller conveyors which extended through window or door openings in the wall of the building. The conveyors were 24 ft. long and wide enough to accommodate a skip; they were inclined at a slight angle to permit a loaded skip to roll from the upper end outside the wall to the lower end inside the building.

TROLLEY CHAIN BLOCK *(below)* traveling on steel beam suspended from cantilevered structural members sets stone in 12th St. facade.



When a skip loaded with lighter stones arrived at the lower end of a receiving conveyor, workmen transferred the stones from the skip to hand trucks or to small individual skips which could be picked up by manually operated 2,000-lb. and 3,500-lb. lift trucks. If the large skip carried a single heavy stone, from one to three 2-ton chain-blocks operating on trolley beams were used to transfer the stone to a smaller skip, which then could be moved to its destination on the floor by a lift-truck of 3,500-lb. capacity. The contractor used two 3,500-lb. lift trucks and seven 2,000-lb. chain-block units to move small skips about the floors.

Setting Stone—Two principal methods were employed to set exterior wall stone; accompanying photographs illustrate both methods. The major portion of the smaller wall pieces were set in

AT FOOT OF ROLLER CONVEYOR, stone is unloaded from skip to smaller skid platforms for distribution on floor.

TRUCK-MOUNTED HAND-HOIST DERRICK counterweighted with stone sets lighter pieces in exterior walls.

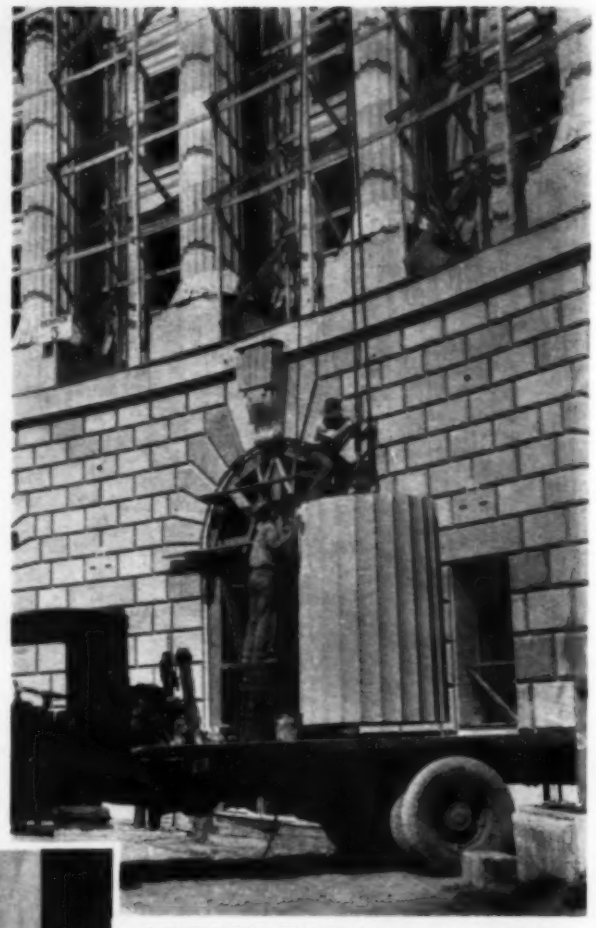
MARBLE COLUMN on 12th St. facade is erected with aid of steel stiff-leg derrick.

place by eight 1,800-lb. full-revolving hand-hoists mounted on rubber-tired trucks or steel casters. Stone counterweights were placed on the rear end of the wheel-mounted platform on which the hoist rests to prevent overturning.

Where exterior cantilever steel members made the practice feasible, the contractor set wall stone with chain hoists running on trolley beams attached to the cantilever members. Cantilever members of this type were required by the architectural design in several parts of the building to carry dental courses and cornices. The trolley beams were suspended from the cantilever members by bolted hangers, as indicated by one of the photographs. Chain hoist equipment in use on the building included three 1-ton, sixteen 2-ton, four 4-ton and one 5-ton units. Practically all the chain hoists of 1- and 2-ton capacity were operated on trolley beams to set wall stone.

To set ceiling stone in the arched driveways and arcades of the first story, the contractor worked out an original application of adjustable telescopic steel-pipe Chicago booms mounted on interior columns above the second-floor level. Five rigs of this type were used to erect interior wall and ceiling stones. Each boom consisted of an outer steel pipe 18 ft. long containing an inner pipe extension which provided adjustment to a length of 24 ft. The lower end of the inner telescopic pipe rested against a steel bolt inserted through holes in the walls of the outer pipe. Holes were drilled in the outer pipe at two points to provide a long or short boom. The boom hoist cables and load lines of the Chicago booms were operated by double-drum hand winches attached to adjacent columns, and the heels of the booms were mounted on swivels to permit rotation of the booms through 180 deg.

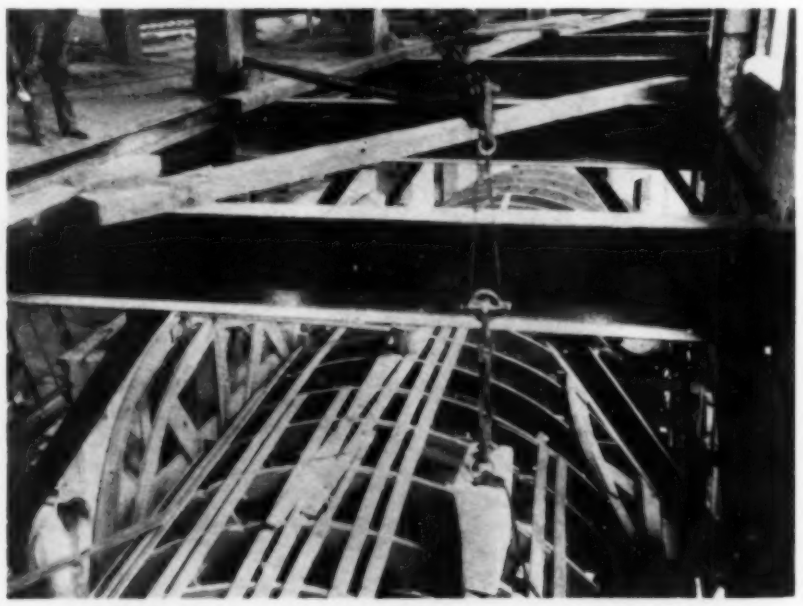
F. H. MARTELL *(left)*, superintendent, and G. A. FEHST, mason superintendent, for S. M. Siesel Co.



LIMESTONE DRUM for column on 13th St. facade is hoisted directly from truck.

Direction — F. H. Martell, superintendent, was in charge of operations for the S. M. Siesel Co. G. A. Fehst was mason superintendent, and V. F. Quinlan contractor's engineer. The work was performed under the immediate supervision of Neal A. Melick, construction engineer, acting under James A. Wetmore, supervising architect of the Treasury Department.

HAND-OPERATED LIFT TRUCK picks up stone on small skid platform and delivers it to convenient location for erection.



CEILING STONE for arcade on first floor is placed by steel-pipe Chicago boom on floor above. Boom is extended to full length of 24 ft.

South Pier Fender Ring and Pylon of

GOLDEN GATE BRIDGE

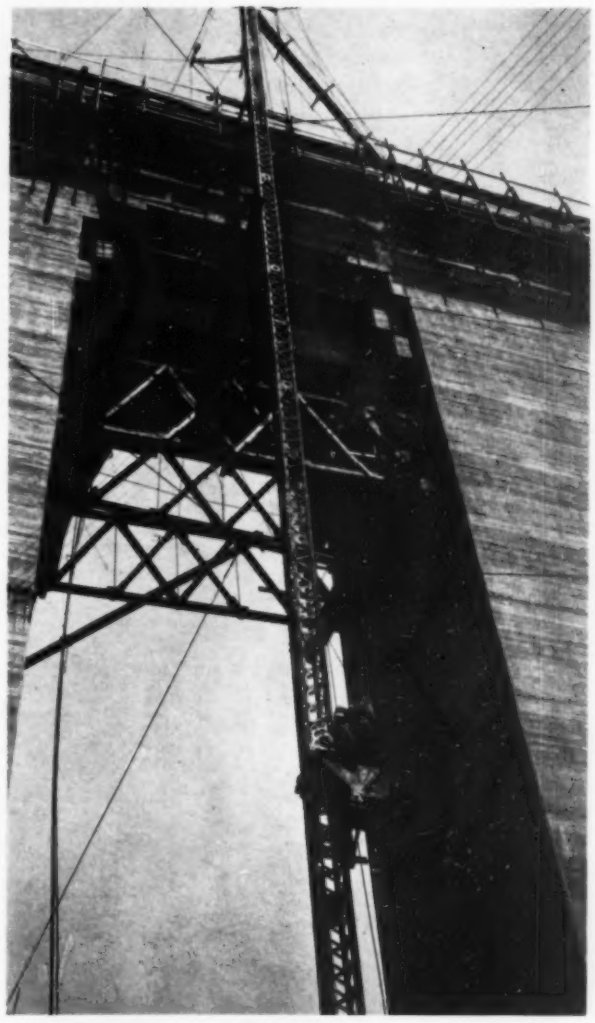
TREMIE CONCRETE being poured in fender ring section. Pouring has been proceeding rapidly, 19,000 cu.yd. having been placed in the ring during the month of August, a total of 59,700 cu.yd. up to Sept. 1. Pouring proceeds 24 hr. per day.

TO PROTECT the south pier of San Francisco's $35,000,000 Golden Gate bridge, with its record-breaking main suspension span of 4,200 ft., the Pacific Bridge Co. is completing a difficult piece of construction in the form of an elliptical fender ring 155 by 300 ft. in plan, which will permanently inclose the pier with a 27½-ft. thick wall of tremie-placed concrete in water 65 ft. deep.

The site of the south (San Francisco) pier, which will support one of the 746-ft. high structural steel towers of the bridge, is 1,000 ft. off shore and is served by a steel and timber access trestle from the end of which timber bulkheads and sectional steel frames with steel plates along the insides are lowered and anchored for use as forms for the concrete of the heavy subaqueous fender structure. The trestle, 24 ft. wide, is built on timber piles for a length of 400 ft. from shore and of structural steel bents set in pipe casings for the remaining 600 ft. With concrete delivered by truck-mixers and deposited under water through tremies, the fender wall structure is poured in vertical lifts from 20 to 40 ft. high.

An opening is left in the fender wall through which to float the 100x 200-ft. caisson for the pier proper. With the caisson inside, the fender wall will be sealed and the caisson sunk within it by the usual process of building up concrete until the structure is seated on the ocean bottom and sealed.

Photos, Standard Oil Co., California



MASSIVE PYLON, 1,100 ft. inshore from south pier, is being given architectural treatment corresponding with finish planned for the steel tower. At south pier the pylon, or cable bent pier, is 140 ft. high.

FIRST SECTION of fender ring to be concreted above water level. Note projecting reinforcing steel at right of concrete. Timber forms are removed by burning through the steel rods across top of section. On Sept. 1, 10 of the 22 sections in the fender ring were in place up to ultimate height of Elev. 15.

CAISSON ready to be towed to the south pier. This caisson is 100x 200 ft. in plan, draws 30 ft. of water and will be sunk inside fender ring. A portion of the ring will be left incomplete until the caisson is towed in. The 22 muck stacks in the caisson are for removing spoil from the bottom.

HAND-LABOR GANGS, distributed nine men to each 2-yd. truck, load 63,000 yd. of earth on highway grading and paving contract in Delaware.

HIGHWAY GRADING

in Delaware Done by Hand Labor and Machines

SKILLFUL management of hand excavation on a highway contract in Delaware enabled the contractor's organization to complete an 11,000-yd. earth cut in seven 10-hr. days, using sixteen 2-yd. dump trucks and eight loading gangs of nine men each. D. E. O'Connell & Sons, Inc., of Wilmington, Del., were responsible for this performance on a 4.76-mi. section of the Coleman duPont dual highway where the contractor is performing both grading and concrete paving. The contract specified that half of the 126,000 yd. of grading should be excavated by hand and the other half by machine. Unit prices were taken for each of the two types of excavation.

FOUR MEMBERS *(below)* of D. E. O'Connell & Sons, Inc. *(Left to right)* Philip J., John J., D. E., and M. E. O'Connell. Fifth member, Frank D. O'Connell, is missing from this group.

With the exception of 1 mi. of relocation, the contract calls for the construction of a 20-ft. concrete roadway parallel with, and 50 ft. from, the existing 20-ft concrete pavement. Total width of the improvement on this portion of the contract is 83 ft., including a 50-ft. parkway between the two roadways, 20 ft. of pavement, and 13 ft. of shoulder and ditch adjacent to the new concrete. On the 1 mi. of new location, where two 20-ft. roadways are being constructed, the dual highway takes a right-of-way 116 ft. wide between toes of slopes.

Machine Excavation — Two 1-yd. power shovels (one operated by steam and the other by gasoline motor) took

TANK TRUCK delivers water to 1-yd. steam shovel, one of two power machines used to excavate remaining 63,000 yd. of earth on contract.

TRACTOR-DRAWN PLOWS loosen earth in shallow lifts for hand loading. Cuts are made by hand to maximum depth of 10 ft.

PAY DAY on job. Portion of 325 men employed in two shifts on grading line up at contractor's wagon office for their money.

care of the 63,000 yd. of machine excavation. These shovels loaded eight 3½-yd. trucks. The two shovels and the hand gangs moved about 3,000 cu.yd. per 10-hr. day.

Hand Excavation — Although the contractor was able to concentrate 16 trucks and a large hand-labor gang in the 11,000-yd. cut mentioned in the first part of these notes (where a sandy soil facilitated loading and increased production), a more nearly typical condition was to be found in the clay cut illustrated by several of the photographs, where 10 dump-trucks and 5 loading gangs were engaged. In addition to the 45 men in the loading crews, this outfit had nine other men acting as workers on the dump and as foremen. Working in stiff clay, the gang was able to move 700 loads per 10-hr. day. Each load contained 2 yd. of loose earth, estimated by the state highway engineers to yield 1½ yd. of settled fill. One day's production of the ten-truck hand-labor outfit therefore represented about 1,050 yd. of material for which payment would be made on the monthly estimate. Average haul for trucks on the hand-labor operations was 1 mi.

Cuts excavated by the hand-labor gang ranged in depth up to 10 ft., which was to be the eventual depth of the grading operation in the photographs. The deeper cuts were taken out in shallow lifts. Two tractor-drawn plowing outfits loosened the earth for loading, with one tractor pulling three plows and another tractor pulling two.

Prices and Progress—The contract was signed Dec. 22, 1933. Specifications required that operations start immediately and continue through the winter. The unit prices for excavation, 70 c. per cubic yard for hand excavation and 28 c. for machine excavation, were based partly on winter costs. After carrying on the work for about 1 month, the severity of the weather caused a shutdown for 2 months. Up to March 1, the contractor had moved 35,000 cu.yd. In the following two months, March and April, the organization moved the remaining 90,000 yd.

Organization—During the progress of the excavation, the contractor employed a total of about 325 men in two shifts. Each shift worked from Thursday to Wednesday, inclusive, making three 10-hr. days per calendar week for each shift.

D. E. O'Connell & Sons, Inc., is a closed corporation, the business of which is managed by D. E. O'Connell and four sons. Mr. O'Connell began his road-building operations 32 years ago. Since that time, the four sons have entered the business. Philip J. O'Connell and John J. O'Connell were resident on the contract and were nominally in charge of operations. Frank D. O'Connell, also resident on the contract, was responsible for equipment and maintenance. The fourth brother with the firm is M. E. O'Connell.

For the Delaware State Highway Department, W. W. Mack, chief engineer, is in charge of all work. The contract was executed under the direction of William A. McWilliams, resident engineer for Kent County.

TWO POWER SHOVELS and fleet of eight 3½-yd. trucks take care of one-half of grading on project. At this point, new 20-ft. pavement of dual highway will parallel old concrete in use at left.

SMALL CREW ON DUMP disposes of earth hauled by ten 2-yd. trucks from clay cut where five loading gangs are working.

ON NEW LOCATION, right-of-way measures 116 ft. between toes of slopes. Hand-labor gangs in background load clay out of cut into trucks which deliver material to fill crossing long concrete box culvert, built on skew, in foreground.

"Sure we're Satisfied..."

WE'VE BOUGHT OVER 20"

"We've used Allis-Chalmers tractors since 1930 . . . have bought over 20 of them," said Jack Dressel, superintendent for J. C. O'Connor & Sons, Incorporated. "Last spring we bought our first Model 'L-O' oil tractor and another oil burning tractor of different make. Since then we have purchased five more A-C oil tractors. Isn't that proof of our satisfaction?

A Five-Year Test

After nearly five years' experience with Allis-Chalmers performance, J. C. O'Connor & Sons, Incorporated, are well satisfied. They get good performance and "good yardage". Your problems are similar to theirs. Why not take advantage of the many A-C features which mean lower cost dirt moving? Let an Allis-Chalmers dealer figure with you . . . He can supply track-type tractors, wheel-type tractors, power controlled graders, hand controlled graders, elevating graders, Speed Patrol graders, power units, track wagons, wagon tracks.

Write for your copy of the Action Magazine.

ALLIS-CHALMERS
TRACTOR DIVISION—MILWAUKEE, U. S. A.

Competent Men

Both Jack Dressel and his brother Bill boss outfits for J. C. O'Connor & Sons. They have a hard time beating each others records because they both use A-C equipment.

Dirt Mover

This bulldozer equipped "K-O" is a necessary part of O'Connor's equipment. Here it is leveling a side road approach on their contract near Brownstown, Ind.

Real Mucker

Above and below are views of the new A-C 48 inch power controlled, power operated elevating grader — a new addition to J. C. O'Connor's equipment. They loaded 350 five yard loads in a 3 hour test. You will look a long time before you find a better-built mucker — or one that moves as much dirt.

Wagon Tractor

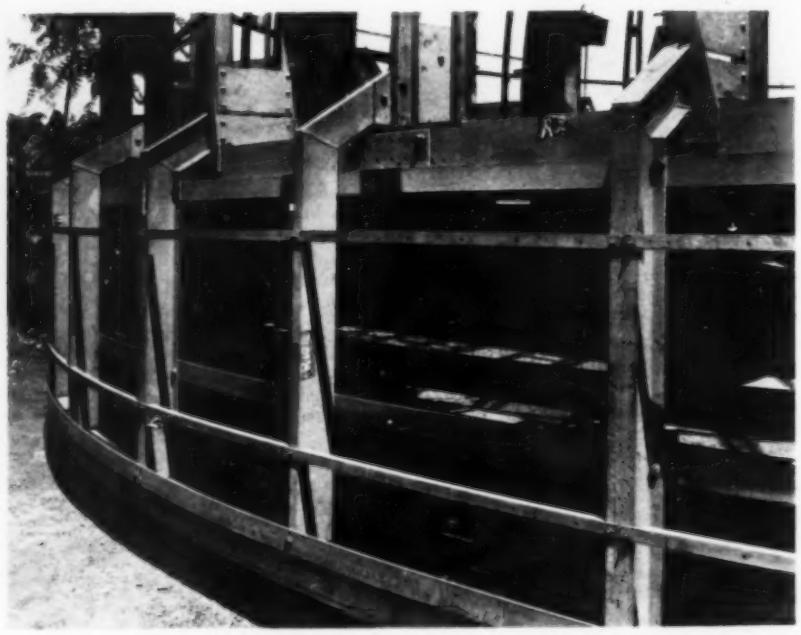
Any contractor who has operated a Model "L" will say it's the best wagon tractor on the market. The new Model "L-O", shown here on the O'Connor job, gives that same dependable, fast performance. Its six speeds forward — up to 6.47 miles per hour — are the same as those of the Model "L".

STEEL DOME

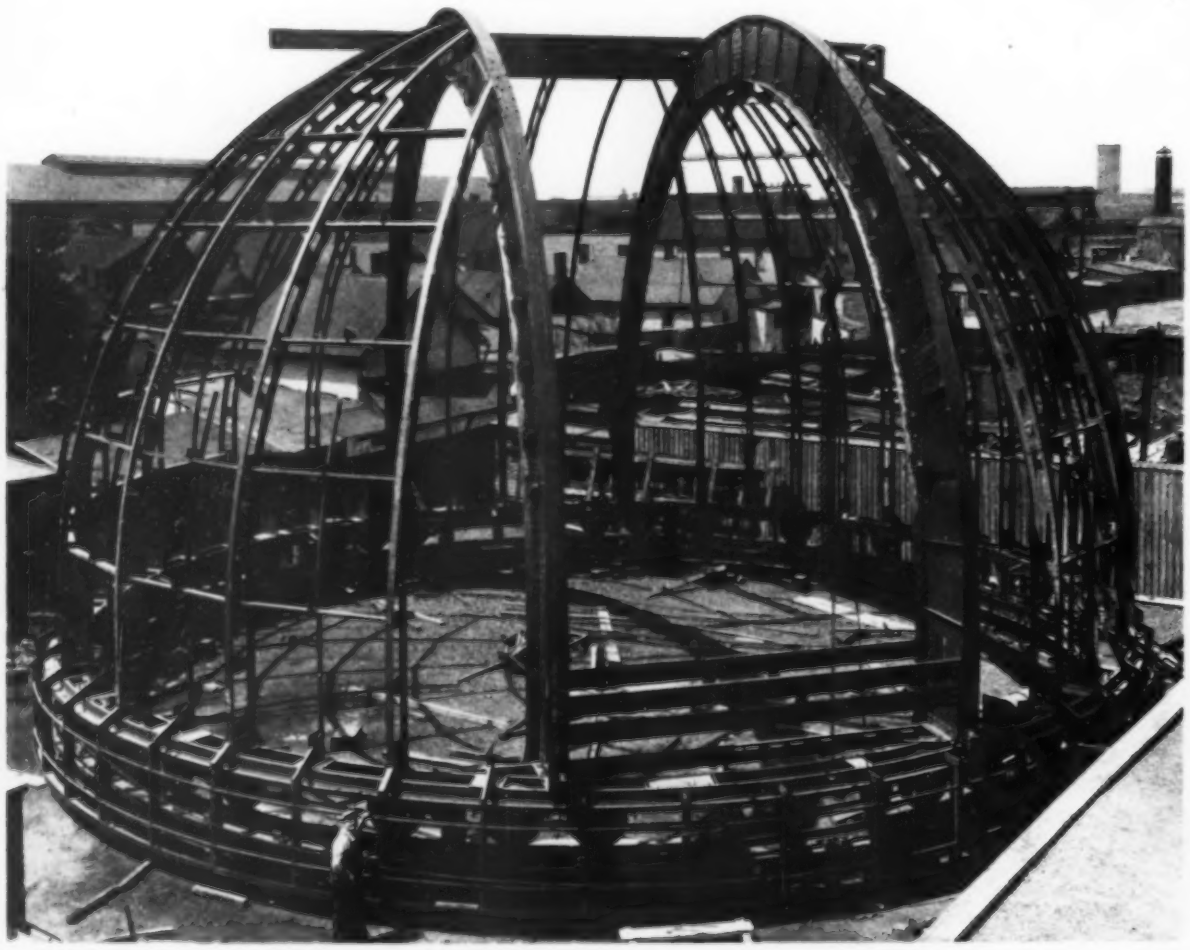
Will House Big Telescope at McDonald Observatory, Texas

FRAMEWORK for a new observatory dome to house the world's second largest telescope started in August on a 1500-mi. journey to the summit of Mt. Locke in southwestern Texas. The structure, fabricated and preassembled in Cleveland with arc-welding playing an important part, is being reassembled near Fort Davis, Texas, 40 mi. from the nearest railroad.

STEEL FRAMING for dome of McDonald observatory, showing slot or telescope opening 16 ft. wide between main curved girders, partially closed by movable shutters.



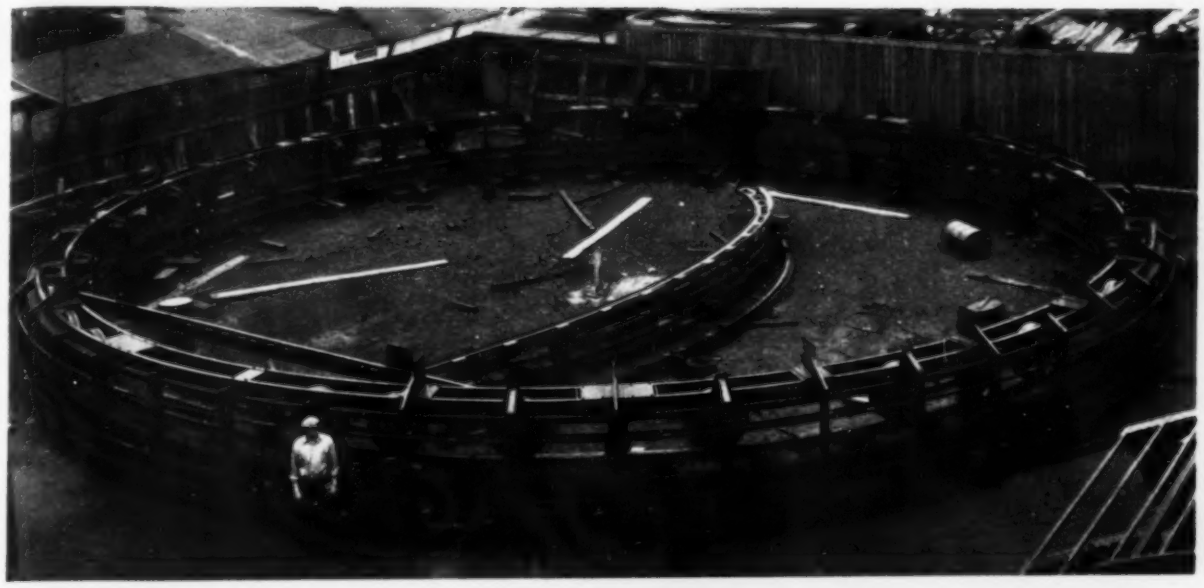
ARC-WELDING is employed extensively to insure rigidity and strength of structure to resist earthquake shocks. Bolts are only for purpose of temporary assembly of members.



REVOLVING DOME *(left)*, assembled in Cleveland before shipment to Texas, has diameter of 62 ft., height of 37 ft. and weight of 125 tons. Completed structure will be sheathed with sheet metal.

There on the mountain peak the structure will be rooted to the earth and protected against earthquake shocks by arc-welded steel bracing. So that astronomers of the University of Chicago and University of Texas, at an elevation of 7,000 ft., may begin new explorations of the solar system, Mt. Locke was chosen as the site of this new observatory because of unusually clear atmospheric conditions. McDonald observatory, as it is to be called, was designed by the Warner & Swasey Co., Cleveland, Ohio, for the University of Texas. In it will be placed an 80-in. reflecting telescope 26 ft. in length.

The dome of the observatory was erected in Cleveland by the Paterson-Leitch Co. under supervision of the designers. The dome is 62 ft. in diameter with a height of 37 ft. Construction of the dome required 125 tons of structural steel. An equal tonnage will be used in the substructure. After the building has been erected on Mt. Locke



CIRCULAR TRACK *(above)* of 80-lb. rail carries base ring of 10-in. channels reinforced with 6-in. I-beams.

it will be covered with about 25 tons of galvanized iron sheets.

Floors of the structure are of the "battle-deck" type, entirely arc-welded for rigidity. The first floor of the supporting structure will be used for libraries and offices. The second floor will contain sleeping compartments, laboratories and photo developing rooms.

Two main girders and a base ring constitute the main structural members of the dome which is mounted on a plate and girder base fastened to the top of the columns of the observatory building. The main girders are 4 ft. 6 in. deep with ⅜-in. web plates, 8x 6x½-in. bottom chord angles and 6x6x ⅜-in. top chord angles. The semi-spherical contour of the dome is formed by the shaping of auxiliary ribs which are fastened to the main girders and base ring. These auxiliary members are alternately 3-in. and 4-in. channels and split beams. Skirting hangers are welded construction and fastened to the auxiliary ribs.

Two 10-in. channels, reinforced by a 6-in. beam form the bottom ring. These channels are joined with the flanges facing each other.

The supports for the conductor bars, brackets, as well as the shield which prevents dirt getting into electrical conductors, are all of arc-welded construc tion.

An open space 16 ft. wide between the main girders extends from the base of the dome to a point 9 ft. beyond the peak. This opening is covered by two moveable shutters. Although the shutters weigh 16 tons they are so balanced that they are quickly and smoothly opened or closed by a 2-hp. motor. Four movements of the dome mechanism are provided by push-button control within easy reach of the astronomer. The dome will revolve on twenty-six 30-in. wheels running on 80-lb.

LATERAL GUIDE WHEELS and rail grip insure proper revolution of observatory dome on track.

standard T-rail tracks mounted on the top girders of the substructure. The dome-turning mechanism is cable-driven by a 5-hp. motor.

Access to all parts of the dome and telescope is provided by an arc-welded electrically-moved observing bridge running from the base to the top of the dome. This bridge is self-leveling. Arc-welded counterweights insure smooth movement of the bridge. A stairway built as an integral part of the dome gives access from the observer's floor to the bridge. Adjustable pulpits extend from the bridge and permit further adjustments of the telescope.

The two semi-circular elevating platforms, arc-welded on either side of the telescope pier, can be raised hydraulically 15ft. above the observing floor. These platforms make it possible for the staff to make observations at lower points of the telescope tube.

Uniform temperature, necessary for greatest accuracy of observation, is assured by circulation of air between the inner and outer sheathing of the dome and substructure. Air enters at the foundation and passes up through louvres at the top of the dome.

To provide maximum protection against earth tremors, the earthquake bracing is entirely arc-welded.

Welding of the structural work, trucks, counterweights, observing platform, stairways, doors and window frames, railings, flooring, earthquake bracings and other welded parts is done by the shielded-arc process using Fleetweld electrodes and welding generators manufactured by the Lincoln Electric Co., Cleveland, Ohio. Welding will also be employed in the construction of the 26-ft. telescope tube.

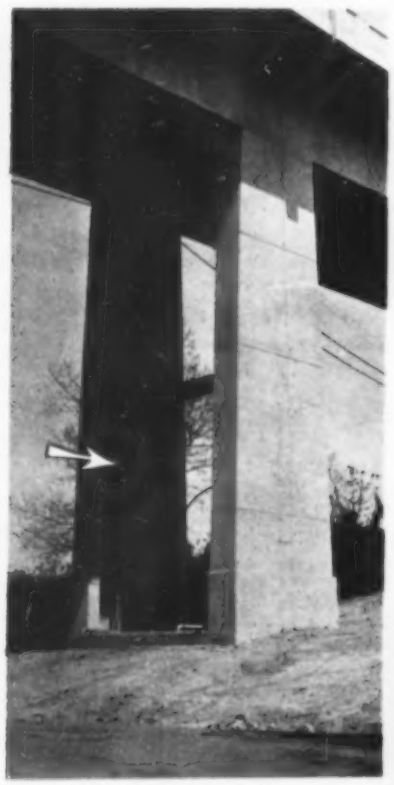
MOVABLE SHUTTERS *(right)* close 16-ft. slot between curved main girders through which telescope will be pointed at heavens

Getting Down to

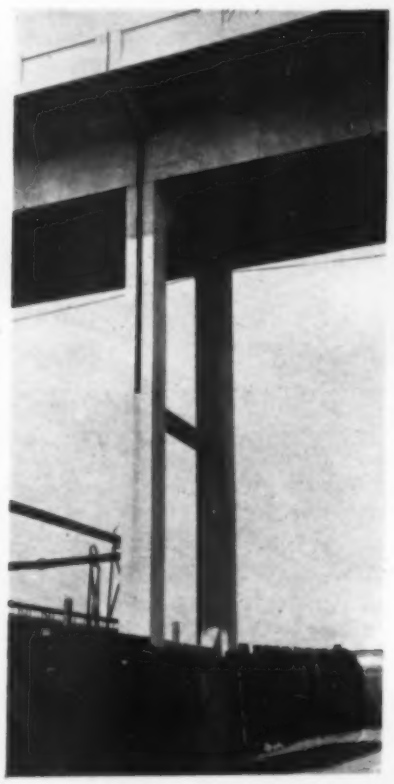
DETAILS

Close-up Shots of
Job Methods and Equipment

TRUCK RAMP at main entrance of United States Supreme Court Building, Washington, D. C., enables George A. Fuller Co., general contractor, to unload marble and other heavy materials inside structure. Ramp passes through stone-cutters' steel scaffold illustrated in *Construction Methods*, August, 1934, p. 41.

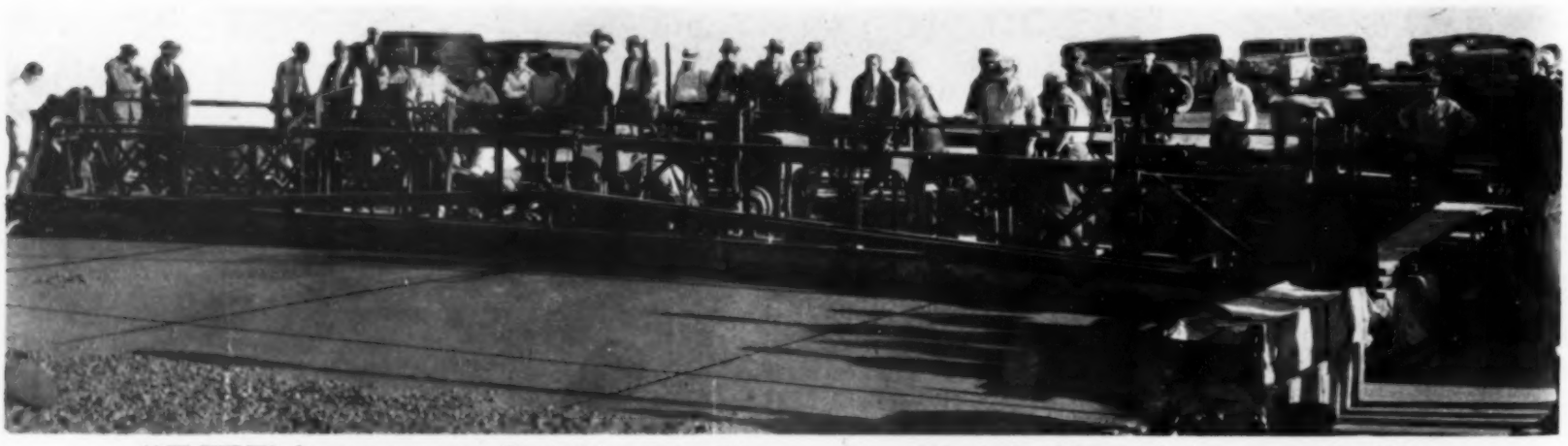


STEEL PIPE DOWNSPOUTS at bents of new Fifth St. viaduct, Richmond, Va., built by T. A. Loving Co., of Goldsboro, N. C., for Richmond Bridge Corp., conduct water from deck to ground and prevent splashing on property beneath, as stipulated in original agreement with property owners about 35 years ago, when public utility concern (Virginia Electric & Power Co.) acquired right-of-way for old steel street-railway trestle.

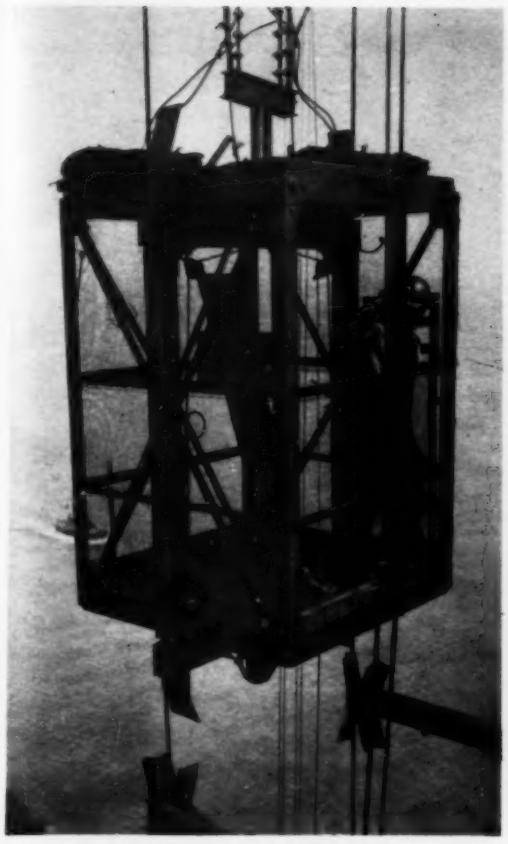


DIVIDED COLUMNS of reinforced-concrete bent of new Fifth St. viaduct, Richmond, Va., provide for movement in deck at expansion joint. Slender divided legs above transverse strut are flexible. Bridge designed by A. C. Janni, of New York City, for Allen J. Saville, Inc., engineer for Richmond Bridge Corp.

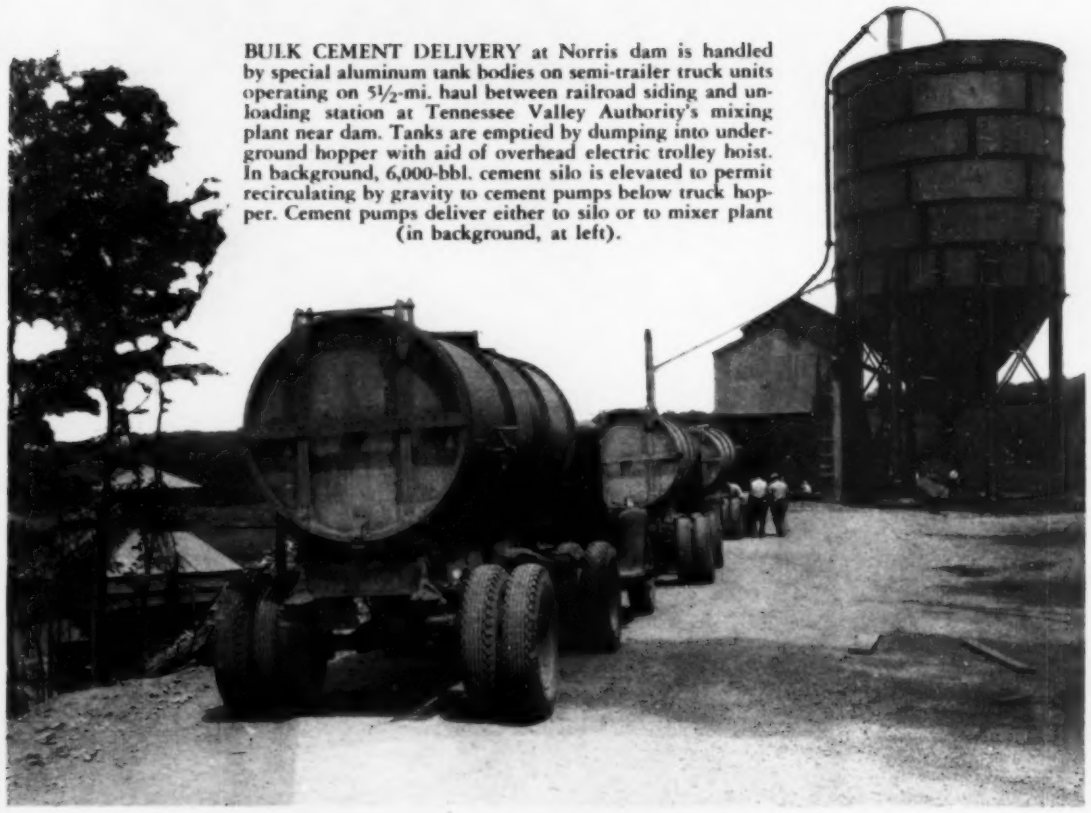
BIG LOAD. On Pilot Knob section of $27,000,000 All-American Canal to irrigate California's Imperial Valley with water from Colorado River, Griffith Co., Los Angeles contractor, is moving earth with large-capacity LeTourneau buggies, each holding 30 cu.yd. Load is discharged at rear by sliding sides along bed of buggy—without tilting or lifting.



44-FT. WIDTH of concrete pavement on Cleveland Ave., Canton, Ohio, is finished in one operation by Garaux Brothers Co., with finishing machine carrying, directly back of screed, three Flex-Plane joint installers which feed ⅛ x 2½-in. asphaltic ribbon (in 100-ft. lengths) into concrete surface for longitudinal joints and also for transverse joints 44 ft. long and spaced 25 ft. apart. Weight of finishing machine for 44-ft. width of street is 6 tons; screed weighs 2 tons. Length of job, approximately 2 mi. Concrete placed by pair of 27-E mixers.

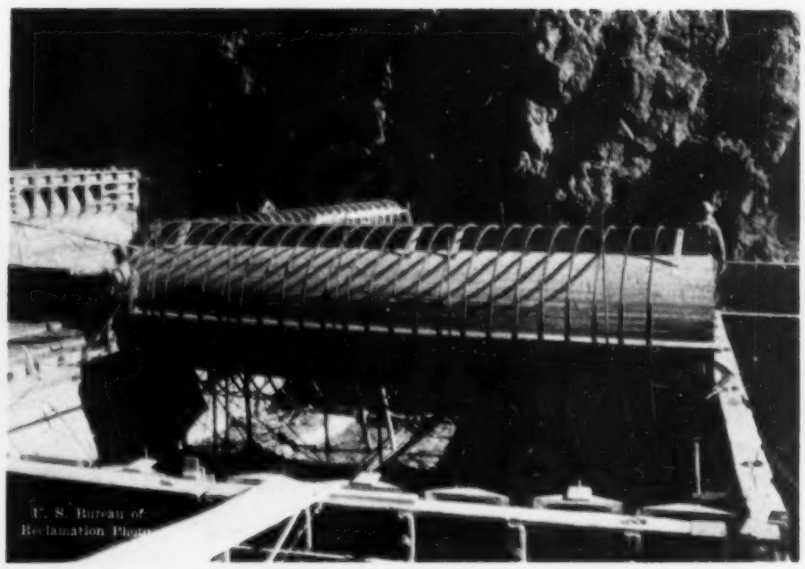


SAFETY CAGE, enclosed by wire mesh, conveys steel erectors to and from high towers of San Francisco - Oakland Bay bridge at vertical speed of 100 ft. per minute. Highest tower is 513 ft. above water level in bay.

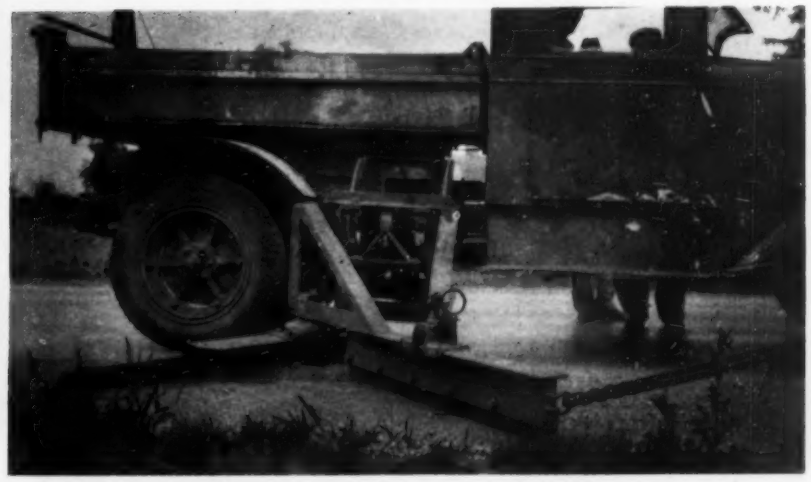


BULK CEMENT DELIVERY at Norris dam is handled by special aluminum tank bodies on semi-trailer truck units operating on 5½-mi. haul between railroad siding and unloading station at Tennessee Valley Authority's mixing plant near dam. Tanks are emptied by dumping into underground hopper with aid of overhead electric trolley hoist. In background, 6,000-bbl. cement silo is elevated to permit recirculating by gravity to cement pumps below truck hopper. Cement pumps deliver either to silo or to mixer plant (in background, at left).

PIPE PONTOONS support 42-in. subaqueous steel water main during assembly and while being lowered as unit 250 ft. into prepared trench across St. Joseph River at Ft. Wayne, Ind. Pontoons, made of standard 42-in. pipe sections with ends closed by light steel bulkheads, were later dismantled and used elsewhere in line. Lowering of pipe was done by hand-operated winches on oak deck sills of pontoons. Construction was by John Dehner, Inc., Ft. Wayne contractor, in association with William C. Curd, consulting engineer of Cincinnati.



RADIAL INSPECTION GALLERY being built by Six Companies Inc. at mid-section of Boulder Dam. View shows arrangement of inside wooden form and steel reinforcement on U. S. Bureau of Reclamation project on Colorado River.



ROAD SHOULDER MAINTAINER, mounted on side of regular motor truck, performs three operations for Indiana Highway Commission: It pulls loose gravel or stone on shoulder up against pavement, levels it down, and, with auxiliary blade, removes surplus from travelled surface of road.

THREE-MIXER PLANT

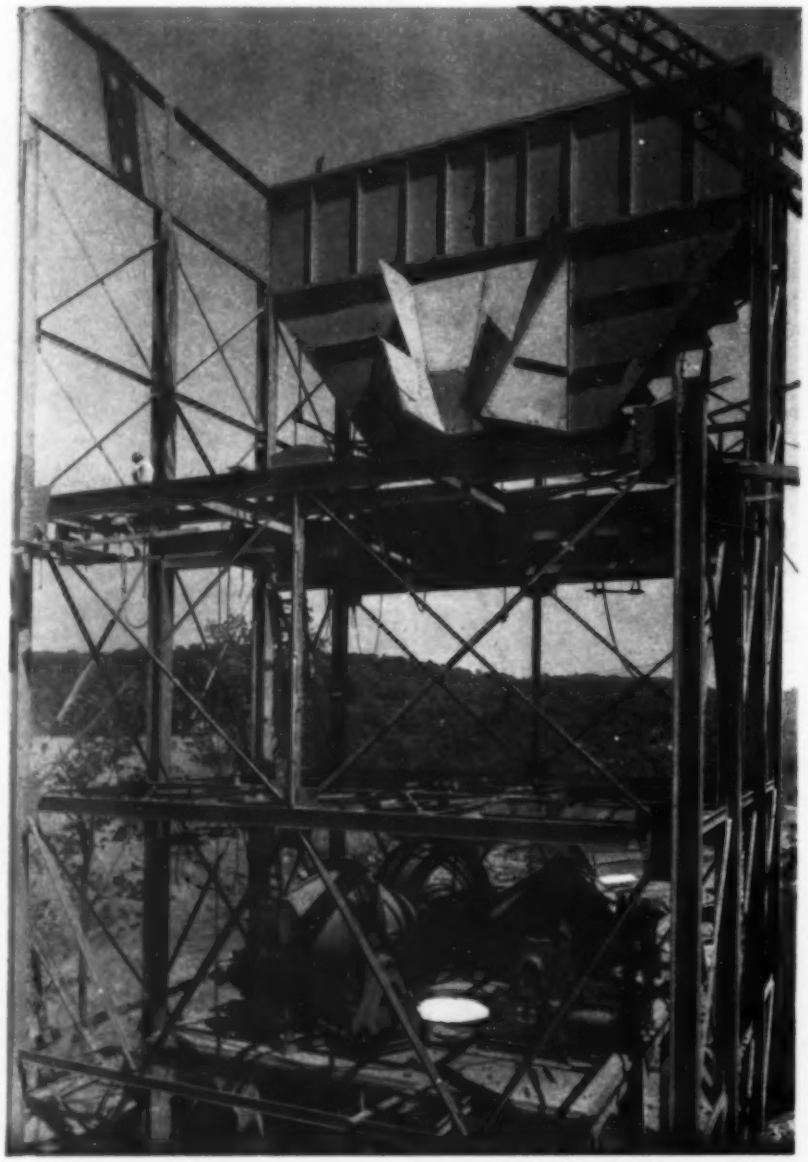
To Produce Mass Concrete, Accurately Proportioned, for TVA's Norris Dam

PLANT and equipment for mixing and delivering to place the 1,000,000 cu.yd. of concrete estimated to be required in building Norris dam of the Tennessee Valley Authority project on the Clinch River in Northeast Tennessee were designed to insure accurate proportioning with a variety of mixes, thorough mixing and complete synchronizing of the numerous units and machines involved. The mixing plant, one of the most modern and efficient units of its kind, has a rated sustained capacity of 180 cu.yd. an hour. Experience in operating the plant on the first 75,000 yd. placed indicates that an output probably 20 per cent in excess of that capacity may readily be maintained.

Character of Materials to Be Handled—Both the sand and crushed rock used in the concrete for Norris dam are being produced from a deposit of dolomitic limestone adjacent to the site, as described in *Construction Methods*, September, 1934, pp. 42-45. Two sizes of artificial sand are employed: fine sand that passes a No. 8 screen and has all the 100-mesh material removed; coarse sand that is retained on a No. 8 screen and passes one having ¼-in. mesh. Four sizes of crushed rock are used, ranging as follows: 4-mesh to ¾-in.; ¾-in. to 1½-in.; 1½-in. to 3-in.; 3-in. to 6-in. The latter size may run slabs 12 to 18 in. long.

The plant for producing these various sizes of sand and stone was described in the article above mentioned. The sand and stone are delivered to the mixing plant, in one grade at a time, by an inclined conveyor leading to a partitioned receiving hopper in the top of the structural steel tower containing the batching and mixing plant. Bulk cement also is pumped to this hopper from an adjacent silo to which dump tank-trucks bring it from an unloading plant at the railroad 5 mi. distant.

Batching and Mixing Plant—Directly upstream from the site of Norris dam the high bank on the right side turns at right angles into a steep, narrow valley. The batching and mixing plant is placed in this angle, with the material-handling plant up the narrow valley on the same side and the quarry directly across from the head of the valley. In this location, near the upstream end of the travel of the head towers of the two cableways spanning the site of the dam, the haul from the mixers to the point where buckets on the cableways may be charged is reduced to a minimum.



STRUCTURAL STEEL TOWER *(above)*, 105 ft. in height, houses concrete mixing and batching plant. Three tilting mixers *(below)*, each of 3-cu.yd. capacity, are set radially on separate concrete foundations to eliminate vibration on batcher operation deck above.

In the design of the batching and mixing plant it was contemplated that the structural steel tower containing the plant and the equipment installed would be used on future dam projects of the T.V.A. The 5-story steel tower, 105 ft. in height, the storage bins of the plant and various other parts were accordingly erected with rivet bolts to permit easy dismantling and re-erection.

In the top of the tower is a headhouse containing a manually-operated turn-head hopper under the end of the conveyor leading up from the tunnel under the sand and broken-stone storage piles. This hopper feeds any one of six material bins directly under it. Two bins for cement, each with a capacity of 470 bbl., are fed directly from a pipe line leading from the pumps in the adjacent receiving plant for the tank-trucks.

Bins for the fine and coarse sand, the largest size gravel and the large cobblestone each have a capacity of 210 cu.yd., while bins of only 140-yd. capacity are provided for the two smaller sizes of gravel. These bin capacities were adopted to fit normal requirements of the plant for the proportions of the bulk of the concrete used in the dam.

Directly under the hopper-shaped bottoms of the several bins is a tight-deck floor at which level are located two batchers for cement, one for each size of stone and sand and one for water. These batchers are arranged in two batteries, with five in one battery and three in the other. Each battery is separately controlled by means of manually-operated air valves on the aggregate batchers and automatic push-button control on the cement batchers. One man handles one battery and a second man the other.

Through a motor-driven turn-head hopper on the deck under the batchers these feed into any one of three 3-yd. tilting mixers. The latter are set radially to discharge through the same hopper into cars at the level of the base of the tower. The mixers are mounted on a reinforced-concrete platform carried by concrete columns independently of the main steel tower to eliminate vibration on the batcher operating deck of the tower.

TRANSFER CARS *(above)* carry pair of tilting 4-yd. skips, hauled from concrete mixing plant to cableway by gasoline-electric standard-gage locomotives.

BOTTOM-DUMP BUCKET *(left)* of 6-cu.yd. capacity is carried by cableway to point of discharge within forms at damsite.

Details of Batcher Equipment—Suspended independently from the bottom of the storage bin, each batcher for cement and aggregate has its own weighing scale, as illustrated. The water batcher is placed at one corner of the same deck of the tower. Located on this deck is an inspector who receives by telephone all instructions from the points on the dam where concrete is being placed. Without leaving his position he is able to accomplish changes in mix rapidly by means of signals which will be explained later.

All sand and aggregate filling gates are of the radial undercut type, with port openings of sufficient area to permit a gravity flow through them at the rate of 20 tons per minute when completely opened. The batch hoppers have ¼-in. liner plates in all except the hopper for the cobble-sized stone in which ⅜-in. plate is used. The discharge gate on each batcher hopper has a port opening of sufficient area to permit gravity discharge of the full content in 7 sec.

All filling and discharge valves are operated by air rams manually controlled and capable of practically instantaneous opening or closing. The rams are air-cushioned at the end of the stroke, to prevent damage when operated for instantaneous opening and closing of the batcher gates. The air valves for controlling the filling gates are adapted to group mountings and are so designed as to enable the operator to open or close instantly, to open or close slowly, and to hold the filling gate in a partially open position.

Each cement batcher hopper is equipped with a rotary-type filling gate, having a capacity of 3,000 lb. of aerated cement per minute. This feeder is operated by a fully-inclosed gear system, driven by a totally-enclosed fan-cooled induction motor equipped with a positive and quick-acting magnetic brake. At the top of the cement batcher unit is also an emergency sliding gate directly ahead of the filling gate. Discharge of the cement batcher unit is controlled by an air-operated gate faced with live rubber and covered by a dust guard. The opening controlled by each of these discharge gates is sufficiently large to permit the full batch unit to be emptied in 7 sec.

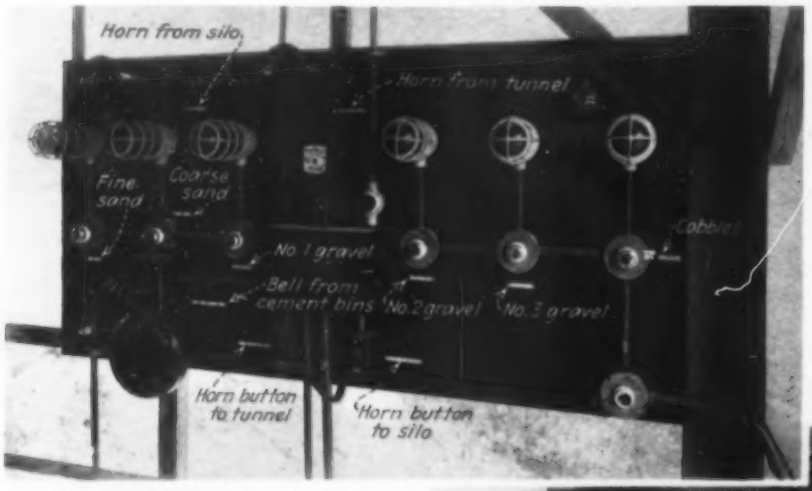
Electric control is provided for starting the filling of each cement batcher unit by means of a push-button. After a predetermined amount of cement has been weighed out, the cutoff is automatic. Electric interlocks are provided to prevent operation of the filler gate when the discharge gate is open, and also to prevent batching when the batcher is full. Provision is made for disconnecting the automatic filling feature, so that it may be placed under manual control if desired. Only one cement batcher is used at a time, the other serving as a standby unit.

The scale with which each batcher is equipped is of the pendulum or springless dial type, swivel-mounted and adjustable for leveling. The dial mechanism is equipped with an adjustable dampening device for steadying the pointer movement. Each dial is equipped with five adjustable pointers, mounted on the outside close to the dial face. Each pointer carries a small lamp socket for a miniature electric signal light. Each pointer is set for a different mix and the light is "on" on the particular mix which is in demand.

One volumetric water measuring tank with a capacity of 200 gal. is installed. This tank is closed and provided with an automatic overflow consisting of a motor-driven, screw-operated riser within the tank. With this device the amount of water delivered may quickly be changed. Gages show the inspector and also the main operator of the batcher plant the water level in the tank. Water is delivered to the measuring tank through a 4-in. valve and discharged through one 5 in. in diameter. Both the inlet and outlet valves are of the quick-acting type and are interlocked to prevent direct flow from the supply to the discharge line. Both valves are actuated by an air cylinder which, in turn, is controlled by an air valve located on one of the control panels.

Control Stand—Two control stands

are provided, as shown in accompanying photographs and drawings. Filling of the batchers is manually controlled by means of air valves. The batcher operators merely observe the dial scales



PANEL BOARD at top of mixer plant carries operating lights and signals to aggregate storage tunnel for delivery of various types of aggregate.

until the needle is opposite the illuminated pointer, and then close the valves. It is possible to maintain the proportion with an error of less than 1 per cent at the comparatively high speed at which the plant is operated.

Four-way batcher dumping valves with 45-deg. lever movement and no shut-off position are installed. Air is admitted at all times to one side or the other of the cylinder. The valves also permit the control of the intermediate position of the cylinder to secure the range of operation of the filling gate previously mentioned.

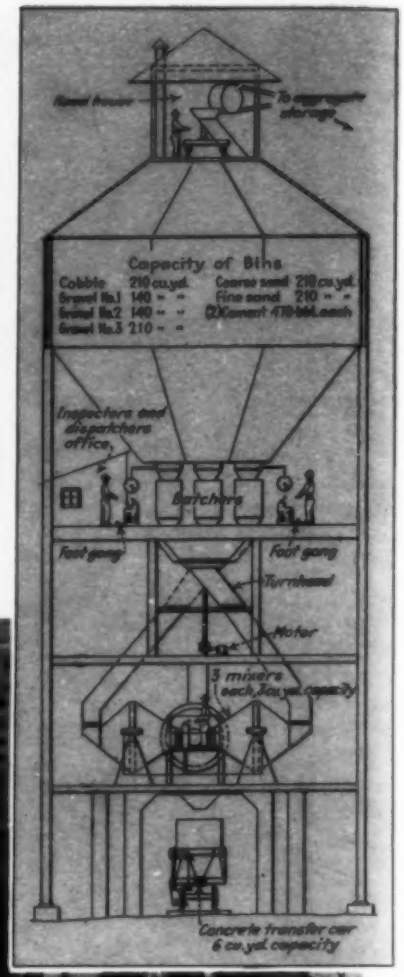
On control stand No. 1, one air valve is arranged to dump both the sand batchers simultaneously and one valve can dump the three gravel batchers simultaneously. Separate valves are provided for dumping cement, water and cobbles. The proper sequence of dumping these valves is important to assure rapid charging of the mixers. The cobbles are dumped last to set up enough vibration in the hopper and chutes to clean them out completely.

Delivery to Mixers — All of the batchers, except for water, deliver through a single collecting hopper directly under them. This hopper carries a motor-driven turnhead for delivering the batched materials to any one of the three mixers. Water is delivered directly to any one of the three mixers by a similar turnhead spout mounted on the same shaft with the main turnhead.

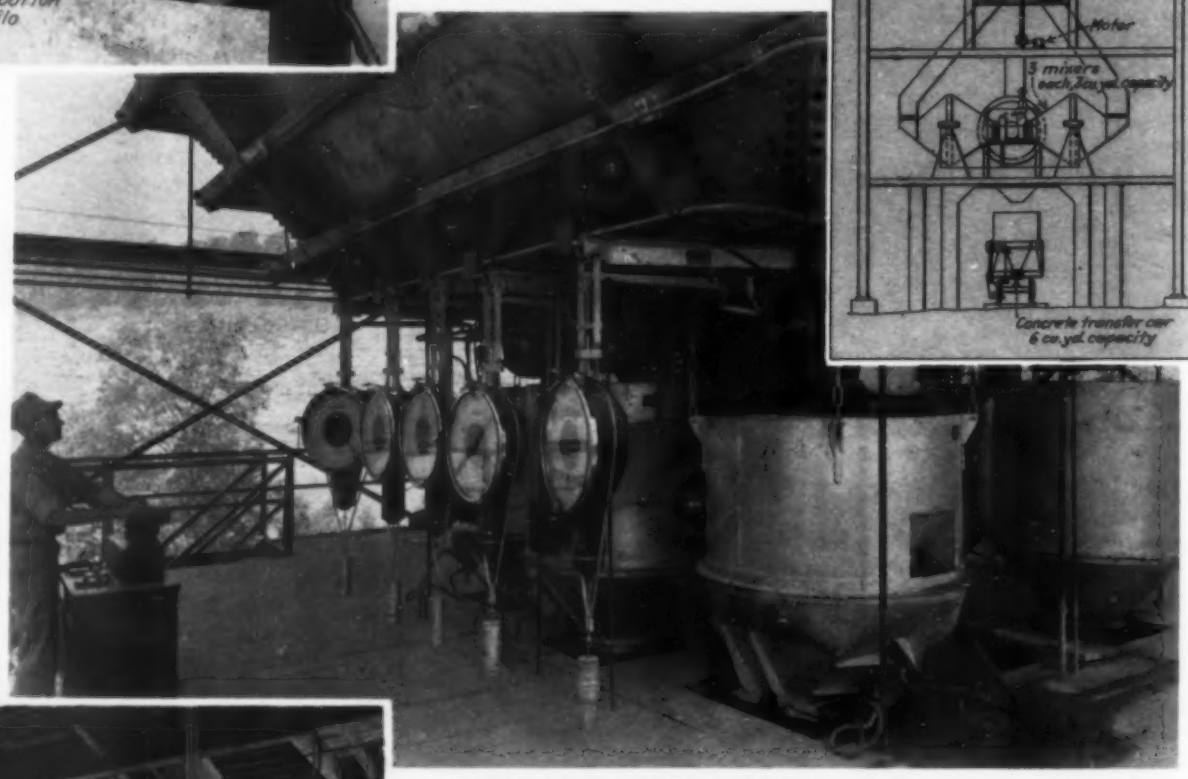
Arrangement and Control of Mixers —Each mixer is independently driven by a 40-hp. motor mounted on the mixer frame and connected to the driving mechanism by means of a rope drive. The mixers are in general of standard design with the exception that a wear-resisting coating is applied to the interior to resist abrasion. This coating is 5/16 in. thick where the wear is heaviest and tapers down to 1/8 in. where the least wear occurs.

Tilting of each mixer is controlled independently by an air cylinder manipulated by a control valve. All three valves are grouped together at one point on the platform immediately adjacent to the mixers. One operator is thus able to handle all three mixers. Each mixer also is equipped with a timer. These timers are mechanically interlocked with the mixer charging system so they begin to function when the mixers are charged. The timers, in turn, are arranged so they automatically lock the air valves and prevent the mixers being dumped until the full mixing time has elapsed.

Push buttons for starting and stopping each of the mixers are placed where the operator may easily reach them while seated on the platform. The operator also has signal buttons to the batcher operators in order to indicate to the latter when each mixer is ready to be charged. A light panel on the platform indicates to the mixer operator when changes of mix occur.



LAYOUT *(right)* of mixing plant, showing relation of bins, batchers and group of three tilting 3-yd. mixers.



AGGREGATE BATCHERS and scales suspended from storage bin. Batchers are air-operated from panel board at extreme left. Filling of each batcher is manually controlled by observing group of dial scales.

CENTRAL OPERATING STAND controls the three 3-cu.yd. tilting concrete mixers installed on concrete foundation separate from structural steel tower to eliminate vibration.

Operation of Plant—The operating staff for the entire batching and mixing plant is composed of 1 foreman, 2 batcher operators, 1 mixer dumper, 1 maintenance man, 1 inspector and 1 belt conveyor operator at the top of the bins. Detailed instructions and signals have been worked out so that manual control is simple and chances for mistakes practically are eliminated.

Operation and maintenance of the head-house equipment is handled by a man stationed on the top deck. From this position he can signal with an electric push-button to the cement silo when to start and stop the cement pump, receiving in acknowledgment a pre-arranged signal on a horn at his station. In the same way he can advise by electric push-button what type of aggregate is needed, when to start delivering and

when to stop. Signals are also arranged to acknowledge his instructions by means of blasts on a horn.

When the dispatcher on the batcher deck receives instructions from the dam by telephone to change from, say, mix A to mix B, he merely turns off switch A on his control panel and turns on switch B. The B light on each scale is now on and the batcher operators proceed with filling until the scale needles are opposite the B lights. The dispatcher can, by means of a toggle switch, cut out any batcher desired and has a light on his board indicating that the batcher has been eliminated. He also adjusts the water batcher, and controls movements of the trains and cableways. Changes of mix are accomplished without a moment's loss of time from normal operation.

Batcher Operator No. 1 has a foot gong to signal Batcher Operator No. 2 on the opposite side of the deck. By means of definitely arranged gong signals these men keep in touch with each other's operations and by means of light signals they follow the instructions of the dispatcher and of the mixer man.

With the devices provided for the mixer man he can check the position of the turnhead and adjust it if necessary. He also signals the batch operator No. 1 when to dump the batchers. Upon release from the mix timer, and after seeing that the transfer car is in position, he dumps the mixer and controls the operation of the transfer car by means of horn blasts.

Transfer Cars—Three standard-gage transfer cars, each drawn by a gasoline-electric locomotive move the concrete from the mixing plant to buckets in which the cableways make delivery to the points where pouring is being done in the dam. On each of these transfer cars is mounted a pair of 4-yd. skips. Each skip is on rocker arms by means of which it is tilted to dump into a hopper at the middle of the car. Tilting of each skip is accomplished independently by a motor-driven mechanism. The operator of the locomotive controls these motors from his cab.

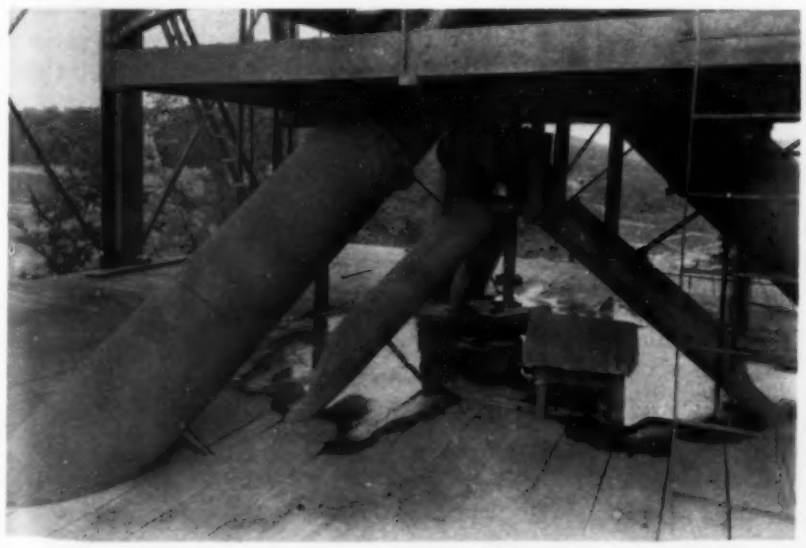
The transfer train operates on a double track leading from the mixer plant to beyond the extreme range of travel of the cableway head towers. This track is arranged with suitable cross-overs so that almost any combination of train movements desired may be obtained. Under normal operating conditions, the trains shift back and forth without the slightest interference.

TRANSFER CAR *(above and in inset)* delivers concrete from mixing plant to cableway pick-up platform. It is equipped with two 4-yd. skips mounted on rocker arms to dump into a hopper at middle of car and thence into cableway buckets. Skips are dumped by electric motor controlled from cab of locomotive.

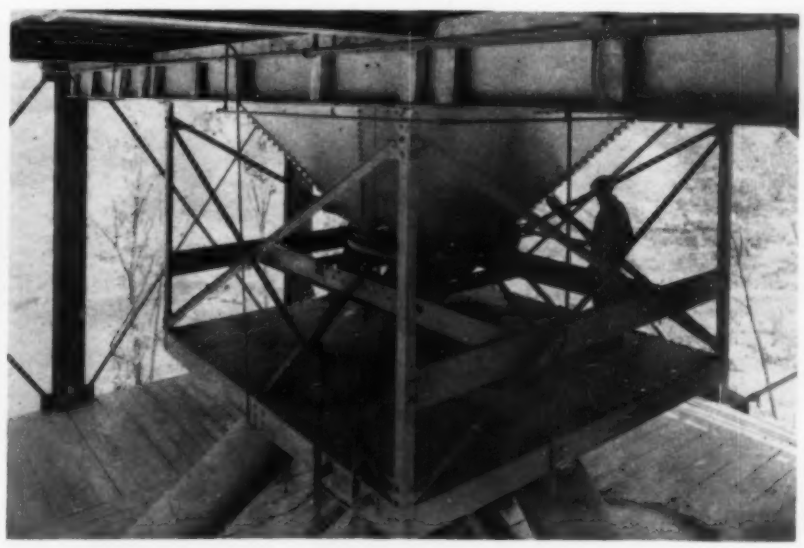
Concrete Buckets—Concrete is handled from the transfer cars to place in the dam in 6-yd., straight-side, bottom-dump buckets, with self-locking gates. Each cableway lowers its bucket on a landing platform at a proper elevation below the track and on the dam side of the latter so that the transfer cars may dump into them by gravity. Each bucket is spotted on the landing platform before the transfer car is shifted to load it. This eliminates the risk of the bucket swinging against the transfer car. The buckets are filled without being unhooked from the fall-block of the cableway, which greatly reduces the time of operation and also cuts out the risk of hooking on and unhooking.

Dumping in the forms is performed by a member of the placing crew, who holds a compressed air nozzle against a port on the bucket and actuates a piston which trips the gate arm. Reclosing and locking of the safety latches is automatic. This system of dumping is very fast and the bucket is in the forms only a few seconds.

In order to reduce to a minimum the



FEED CHUTES to mixers and distributing spout for delivering water from batcher to any of three mixers below.

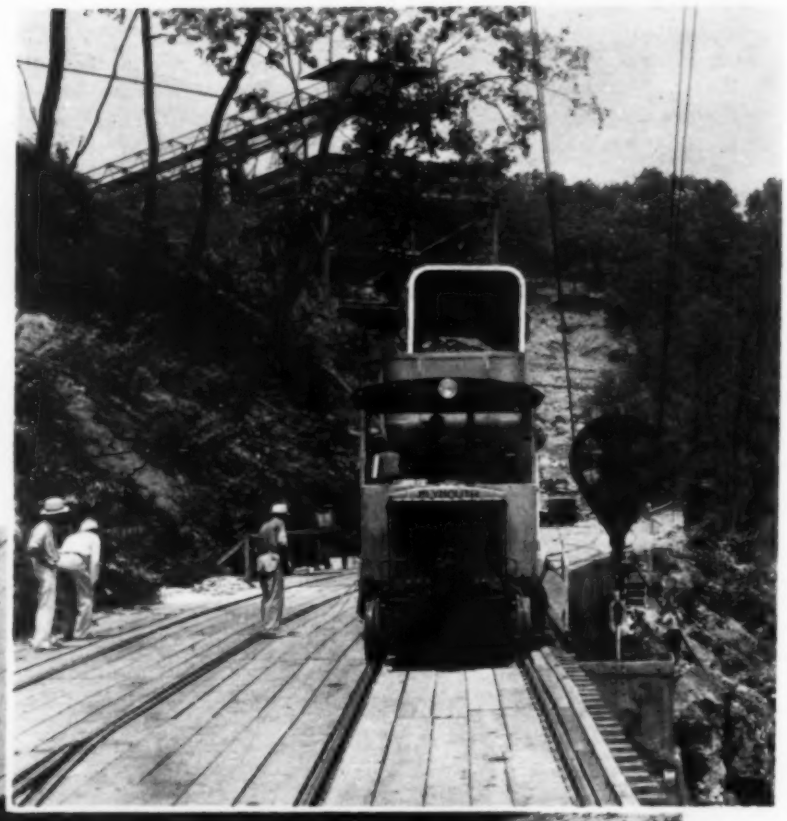


COLLECTING HOPPER below aggregate batchers and turnhead for delivering batched material to any of three mixers.

jump when the cableway buckets are discharged, a simple baffle is hung toward the bottom of each bucket. This baffle is arranged so that it does not importantly reduce the discharge speed. It does, however, control the passage of the concrete out of the bottom of the bucket sufficiently to reduce almost completely the jump of the bucket.

Time and Sequence of Operations—With a 2-min. mix for all concrete, it is readily possible to obtain a 3-min. operating schedule for each mixer. Each transfer car takes the charge of two mixers on each trip. The cableway buckets also hold two mixer charges.

When placing concrete at the extreme depth of the foundation, it has been found that the cableways can easily make a round trip from the landing platform to the dumping position and return in less than 3 min. Each cableway was rated to be capable at this extreme depth of operation to handle 1,500 cu.yd. of concrete in 11 hr. Experience has shown that it is practical to maintain a placing rate of 1,800 cu.yd. in that length of time, at this maximum operating depth. As the height of the dam increases, it is expected that this operating rate may be somewhat exceeded, if that proves desirable.



CABLEWAY BUCKET *(right)* at rest on wooden platform below tracks, receives concrete from transfer car.

CABLEWAYS across site of Norris dam on Clinch River deliver concrete in 6-yd. bottom dump buckets to forms within cofferdam.

TRANSFER PLATFORM *(left)* provides wooden ledge upon which cableway buckets are seated while being filled with concrete from skip of transfer car.

The plant and such special equipment as batcher operating system, cars and buckets were designed by the Tennessee Valley Authority.

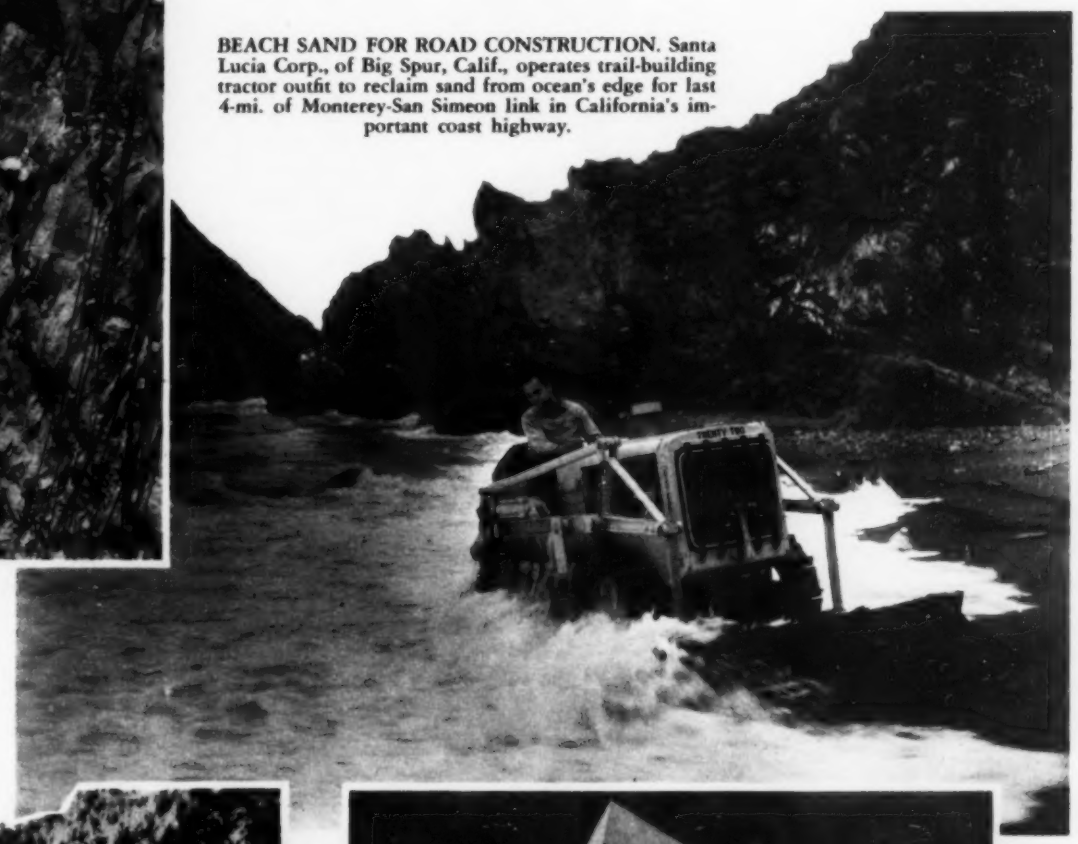
Progress and Personnel—Present indications are that the original schedule for the construction of Norris dam, providing for initial storage of water early in 1936, will easily be maintained and the project completed on time. Quarrying operations are proving very satisfactory, with the character of the rock improving as depth is reached. In manufacturing sand it has been possible to obtain close adherence to rather rigid specifications. Increased sand-making capacity is being installed to permit more rapid operation than was possible with the original units.

A. E. Morgan is chairman and chief engineer of the Tennessee Valley Authority. C. A. Bock is assistant chief engineer. C. H. Locher is construction consultant and A. J. Ackerman is construction plant engineer. Barton M. Jones is construction engineer and C. D. Riddle is assistant construction engineer on Norris dam, with Ross White superintendent of construction and F. C. Schlemmer and E. M. Whipple assistant superintendents of construction.

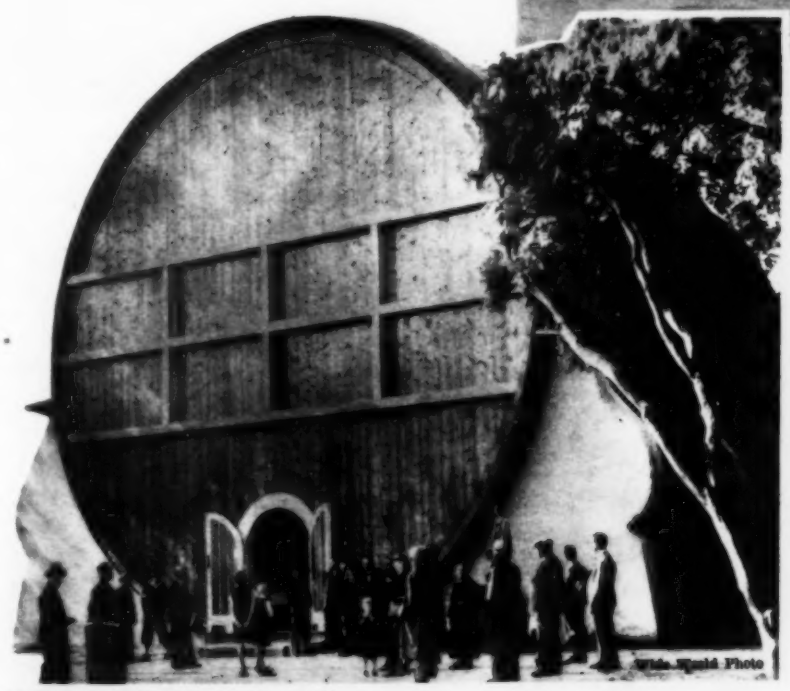
JOB ODDITIES

A Monthly Page of
Unusual Features of Construction

SCALING ROCK *from sidewall of* **lock excavation at Bonneville power and navigation project on Columbia River 40 mi. upstream from Portland, Ore. Guy F. Atkinson Co., contractor.**



BEACH SAND FOR ROAD CONSTRUCTION. Santa Lucia Corp., of Big Spur, Calif., operates trail-building tractor outfit to reclaim sand from ocean's edge for last 4-mi. of Monterey-San Simeon link in California's important coast highway.



350,000 GAL. OF WINE can be stored in huge wooden cask recently erected on concrete foundations at Bad Deurkheim, Germany. It is claimed to be world's largest wine vat.

ENVELOPING WEB *(right)* **of steel scaffolding creeps up sides of Washington monument, Washington, D. C., in preparation for $100,000 cleaning and repairing job — first since shaft was completed in 1884.**

Step-by-Step Field Methods

Wisconsin Widens and Resurfaces Old CONCRETE PAVEMENT

1 OLD 18-FT. SLAB is swept clean before being covered with new concrete.

2 EXPANSION JOINT MATERIAL *(right)* for widening is set in place on subgrade.

IN 1932 and again in 1933 the Wisconsin Highway Department used concrete to resurface and widen to 30 ft. sections of U.S. 42 totaling 7.86 mi. in length, near the city of Kenosha. This work proved so successful that in 1934 an adjacent 5-mi. section of the same highway was resurfaced and widened.

U.S. 42 is the highway connecting Milwaukee with the lake shore cities to the south, including Chicago. It is a heavily traveled road, carrying many trucks between the numerous manufacturing plants in this industrial area.

For the 2.8-mi. section built in 1932 the old 18- to 19-ft. slab first was widened to 30 ft. with concrete that came flush with the top of the old slab. Both new and old slabs then were covered with concrete having a minimum thickness of 4 in.

Design for the 5.06-mi. section built in 1933 was changed and resurfacing and widening were laid in one operation, as a monolith. The widening was not always the same width on each side, but was shifted to obtain better alignment.

Pavement resurfaced in the 1934 op-

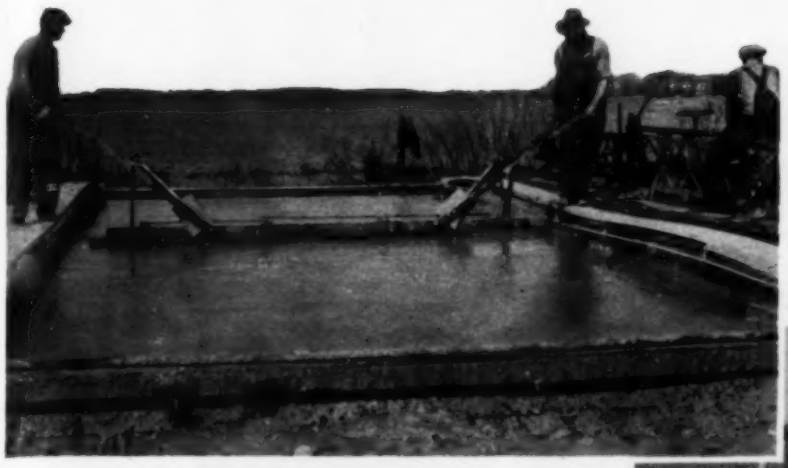
3 STRIKE-OFF TEMPLET, pulled by mixer, levels layer of concrete on which reinforcement is laid.

4 30-FT. SINGLE-SCREED FINISHER *(right)* strikes off and compacts three lanes of concrete.

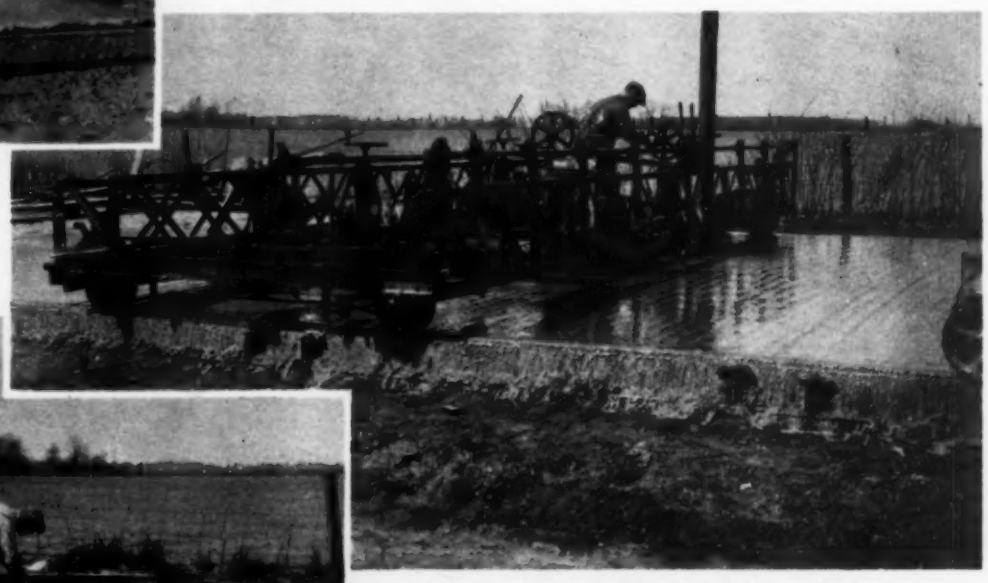
changes in grade or alignment made all new pavement necessary the thickness is 10 in. at the edges and 8 in. in the interior of the slab. A total of 3,752 feet of this cross-section was built. Mesh weighing 56 lb. per 100 sq.ft. was installed over the entire width.

Transverse expansion joints with steel bar dowels were placed at 100-ft. intervals with contraction joints nominally midway between them. Joints were placed exactly over expansion joints in the old pavement, which were spaced approximately 50 ft. apart. A mark was made on the side form indicating the exact location of the old joint, so that the new one could be put in the correct place. Contraction joints also were put over any prominent transverse cracks.

No attempt was made either to produce or to prevent bond between new and old concrete. The old pavement



5 SMOOTH-RIDING SURFACE is assured by longitudinal float that levels any inequalities left by previous finishing operations.



6 30-FT. JOINT MACHINE installs longitudinal and transverse dummy joints.

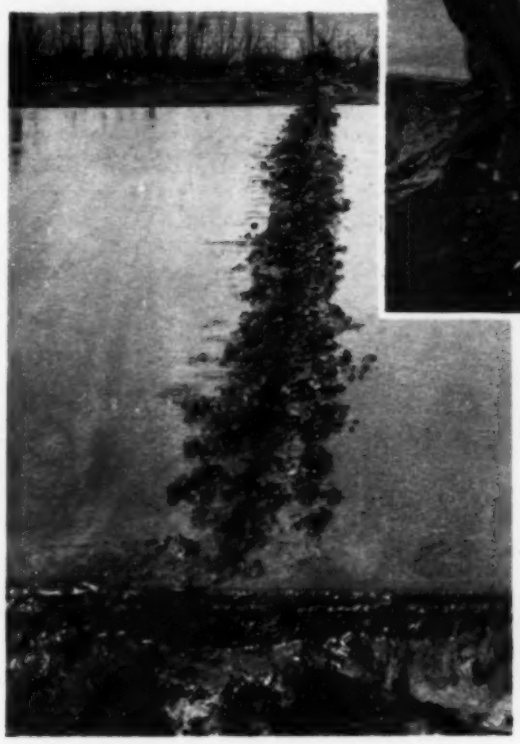
7 FINISHING OF JOINTS is completed from staging that runs on side forms.

9 LAITANCE AND EXCESS MORTAR are removed by scraping surface with straight-edges.

eration is 15 years old. It is a concrete slab 6 in. thick at the edges and 8 in. in the middle. Originally it was only 15 ft. wide, but a 3-ft. shoulder, 7 in. thick, was added later to make a width of 18 ft. The old pavement is not in bad condition, except where fills have settled, but these places were numerous enough to make resurfacing advisable when traffic made widening necessary.

The new slab consists of three 10-ft. lanes. Over the old slab the concrete has a minimum thickness of 4 in. and an average of 6 in. The average thickness is well above the minimum because considerable concrete was used to smooth out grades in depressions and over settled areas.

For the widening the design employed two 6-ft. shoulders, monolithic with the resurfacing, and 10 in. thick. Where



8 AFTER PRELIMINARY FINISHING *(right)*, concrete is cleaned from above expansion joint material.

was swept clean and the new concrete placed directly on it.

Wisconsin ordinarily requires that the coarse aggregate be separated into three sizes; ¼- to ¾-in., ¾- to 1½-in. and 1½- to 2½-in. For this job the 1½- to 2½-in. size was omitted, because smaller size coarse aggregate is needed for slab of the thickness used in resurfacing. Materials were proportioned 689 lb. of cement to 1,632 lb. f sand, with 1,489 lb. of ¾- to 1½-in. limestone and 996 lb. of ¼- to ¾-in.

11 WORKMAN CLEANS loose stones and mortar from expansion joint in preparation for pouring.

10 TWO LONGITUDINAL JOINTS divide pavement into 10-ft. traffic lanes. Transverse contraction and expansion joints separate slabs 30 to 50 ft. long.

ed on both sides of it so that it would not be pushed askew. After the concrete was struck off, concrete above the filler was removed. The upper part of the joint was later cleaned of any loose concrete or stones, and poured full of bitumen. As the portion of the joint in the widening slab was of constant depth, strips of filler of exact width could be used there. These strips were placed on the subgrade ahead of the mixer. A lower layer of concrete on which the reinforcement rested was struck off by a templet pulled forward by the 27-E mixer.

12 POURING POT is used to fill joints with hot bituminous material.

limestone, requiring 6 sacks of cement per cubic yard.

Construction — The whole 30-ft. width was constructed in one operation. A 30-ft. Lakewood single-screed finishing machine struck off and compacted the concrete and a 30-ft. Flexplane machine, operated by two men, made two longitudinal dummy joints and all transverse dummy joints. A separate staging, on wheels, was used by two men who completed finishing the pavement, removed the joint plate and edged the joints.

Expansion joint depth varied considerably, so no attempt was made to have the premolded joint filler exactly the right width. Instead the minimum width, 4 in., was used for all joints. This filler was held upright by a metal cap and concrete was carefully deposit-

13 WIDENED 30-FT. SECTION of U. S. 42 resurfaced with concrete and increased in width from 18 ft.

As the job was a PWA contract, men were limited to 30 hr. of work per week. Two 5-hr. shifts were used daily, the first shift working from 6:30 to 11:30 a.m. and the second from 11:30 a.m. to 4:30 p.m.

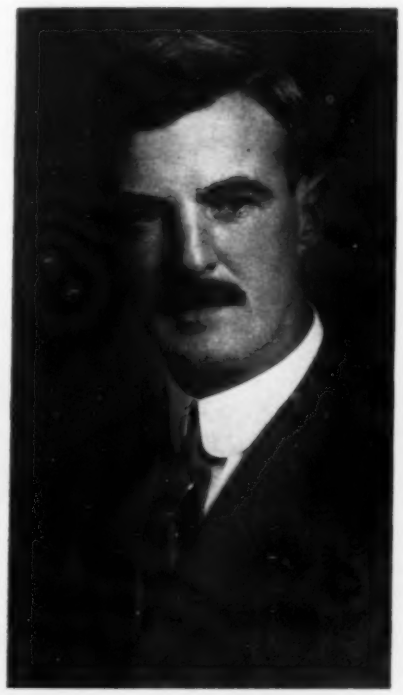
The contract price was $6.55 per cubic yard of concrete, with reinforcement paid for separately. Concrete was measured by counting the number of 33-cu.ft. batches turned out. For the average 6-in. thickness used in the resurfacing, the cost per square yard was $1.09, plus the cost of reinforcement.

Work was done under the direction of the Wisconsin Highway Commission. Joseph Stransky was district engineer and E. J. Gerrits, resident engineer. The contractor was A. E. Bounsall, of Kenosha.

Present and Accounted For —

A Page of Personalities

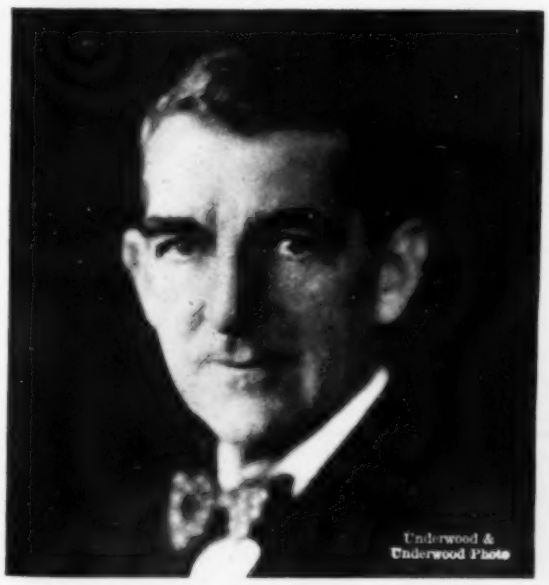
FORT PECK DAM BUILDERS—Major Thomas B. Larkin, Corps of Engineers, U. S. Army *(right)*, and his principal assistant, Major Clark Kittrell, are directing construction on the $60,000,000 Fort Peck dam, river regulation and flood control project on the Missouri River near Glasgow, Montana.



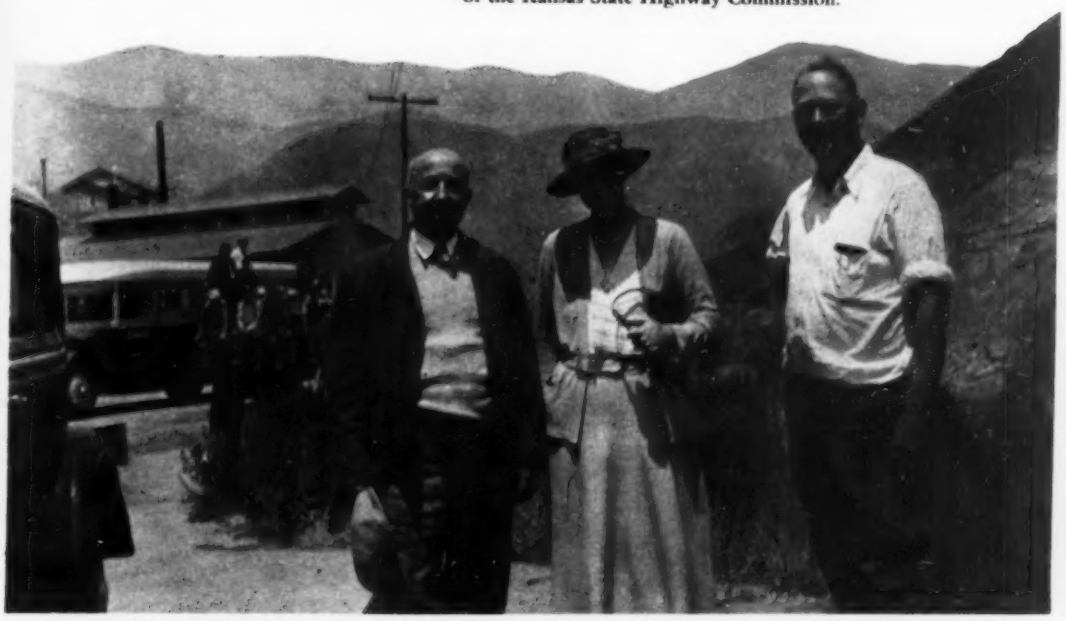
HEADS PHOTO MAPPERS — C. H. Birdseye, of topographic branch, U. S. Geological Survey, has been elected president of the newly organizd American Society of Photogrammetry, comprising leading concerns and individuals engaged in photographic map making.

ROAD BUILDER FOR T. V. A.—Frank W. Webster has resigned as commissioner of the Tennessee State Highway Department to take charge of the road-building program of the Tennessee Valley Authority.

NEW STATE HIGHWAY ENGINEER—H. D. Barnes, who has served with the department since 1920, has been promoted to chief engineer of the Kansas State Highway Commission.



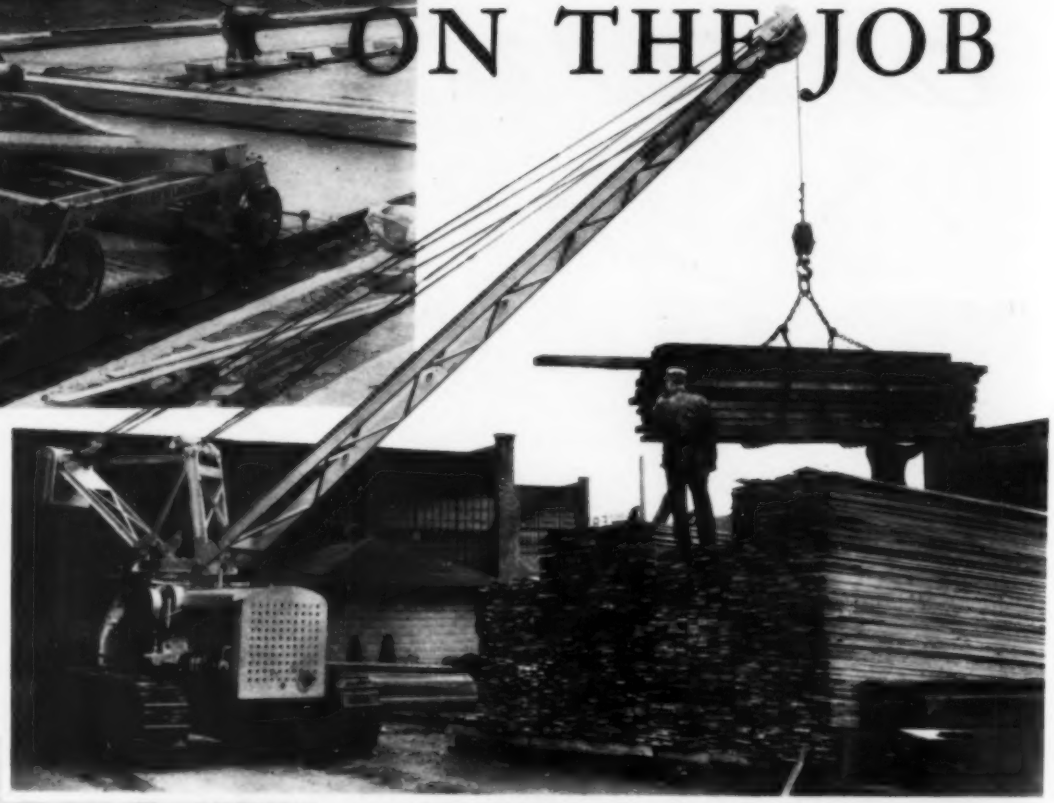
CODE TRIBUNAL CHAIRMAN—Sullivan W. Jones, New York engineer and former industrial advisor to the NRA on the construction code, has been named by President Roosevelt impartial chairman of the National Construction Planning and Adjustment Board.



AT SAN GABRIEL DAM—W. A. Rogers, of the West Slope Construction Co. *(left)*, Mrs. Rogers and K. J. Harrison, resident engineer, inspecting construction of San Gabriel dam No. 1, high rock-fill structure being built in Southern California for Los Angeles County Flood Control District.

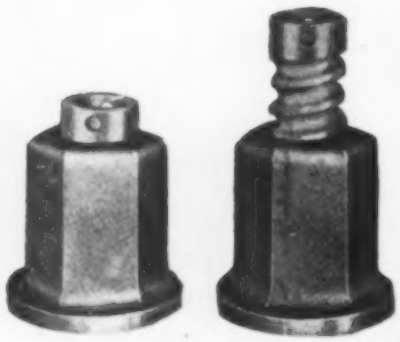
NEW EQUIPMENT ON THE JOB

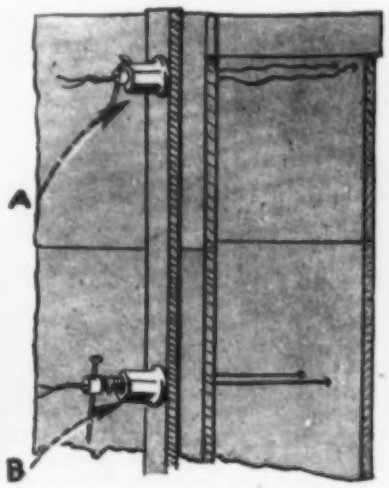
AUTOMATIC HIGH-SPEED FINISHER for widths from 9 to 30 ft. features following improvements: (1) Steers with lever in desired direction; (2) Two men can jack machine up for easy transportation (four corner posts, 9-in. hydraulic jack and telescoping steel pipe furnished in special tool box); (3) Wheels are mounted outside frame for quick adjustment; (4) Curve widening fixtures for 9-10-ft. size finisher provide for extension axles which allow machine to be used on curves widened up to 2 ft., eliminating necessity for setting false forms; (5) Vibrating attachment (direct-mounted). Finisher furnished with gasoline or gas-electric power.—Jaeger Machine Co., Columbus, Ohio.



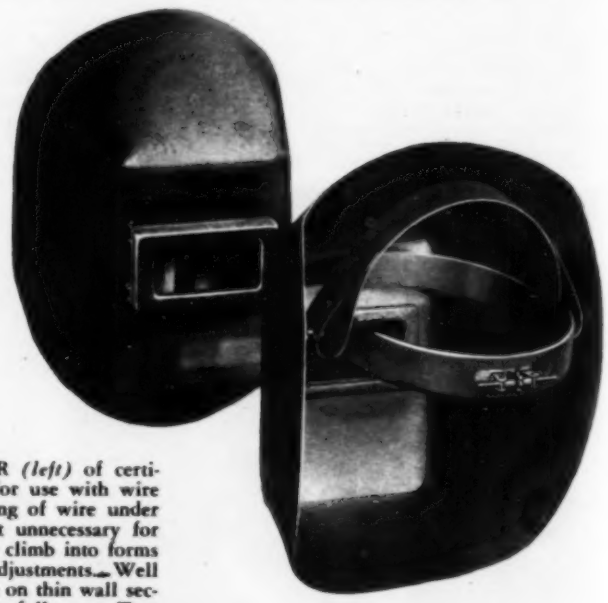
TREBLED CAPACITY, exceptional mobility and fast crane operating speed are three advantages promised for new Loadmaster crane powered by Caterpillar gasoline or diesel engine and mounted on modified Caterpillar tracks. Provided with 30-ft. boom and swings through arc of 240 deg. Lifting capacity, 13,900 lb. at 12-ft. radius. Hydraulic stabilizers mounted between equalizer beam and heavy brackets cast integral with machine frame provide maximum stability for crane when operating over side, even when machine is standing on sloping or uneven ground.—Bucyrus-Erie Co., South Milwaukee, Wis.

ONE-MAN PATROL MAINTAINER with hydraulic-power, finger-tip, ball-lever controls simplify operator's work by enabling him to place blade in correct position quickly without fatiguing effort. Improvements in design provide exceptional visibility for operator; working blade is always within clear view. All-welded box-type structural steel frame with heavy steel plate bracing provides strength and rigidity for resisting all side strain and twist. Weight of machine is balanced to obtain maximum pressure on 12-ft. cutting blade which cuts 9 in. below front wheels and can be shifted 10 in. on either side of center line. Can be used with nearly all makes of tractors.—Austin-Western Road Machinery Co., 400 N. Michigan Blvd., Chicago, Ill.



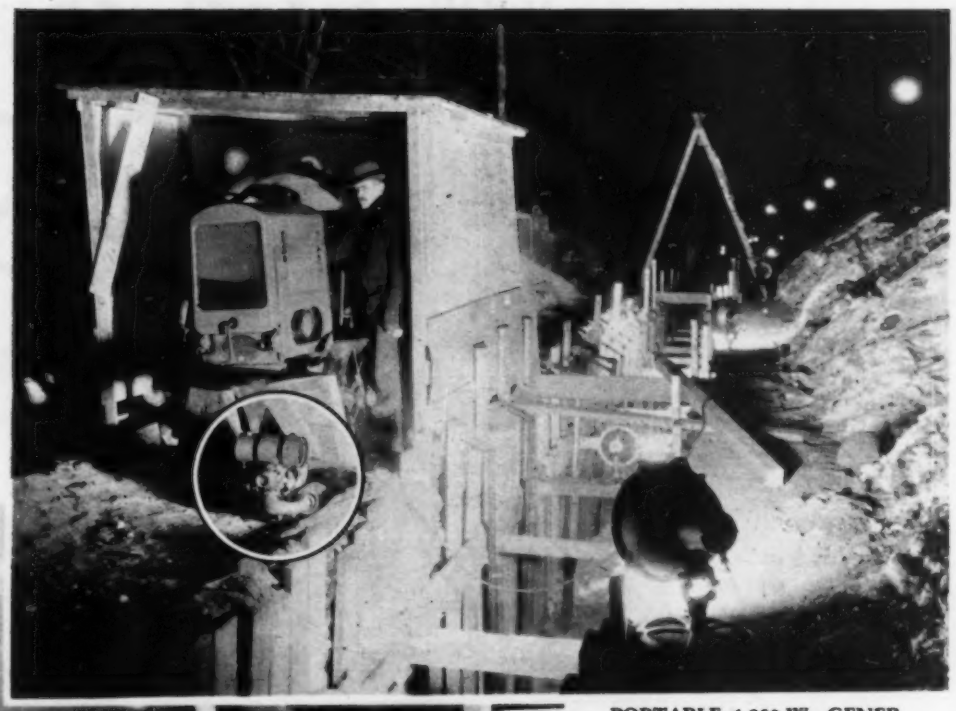


FORM TIGHTENER *(left)* of certified malleable iron for use with wire ties eliminates twisting of wire under tension and makes it unnecessary for workmen to reach or climb into forms to twist ties for adjustments. Well adapted for centering on thin wall sections. Operation is as follows:—Two ends of wire tie are brought through formwork in usual manner and passed through tightener. Nail is inserted through hole in tightener screw, passing between two ends of tie. Wires are given couple of turns, as at A *(left)*, and then workman, holding nail with one hand, uses wrench on nut, making wires taut and drawing forms together to ultimate strength of wire, as shown at B. Tighteners are reclaimable and indestructible.—Marion Malleable Iron Works, Marion, Ind.

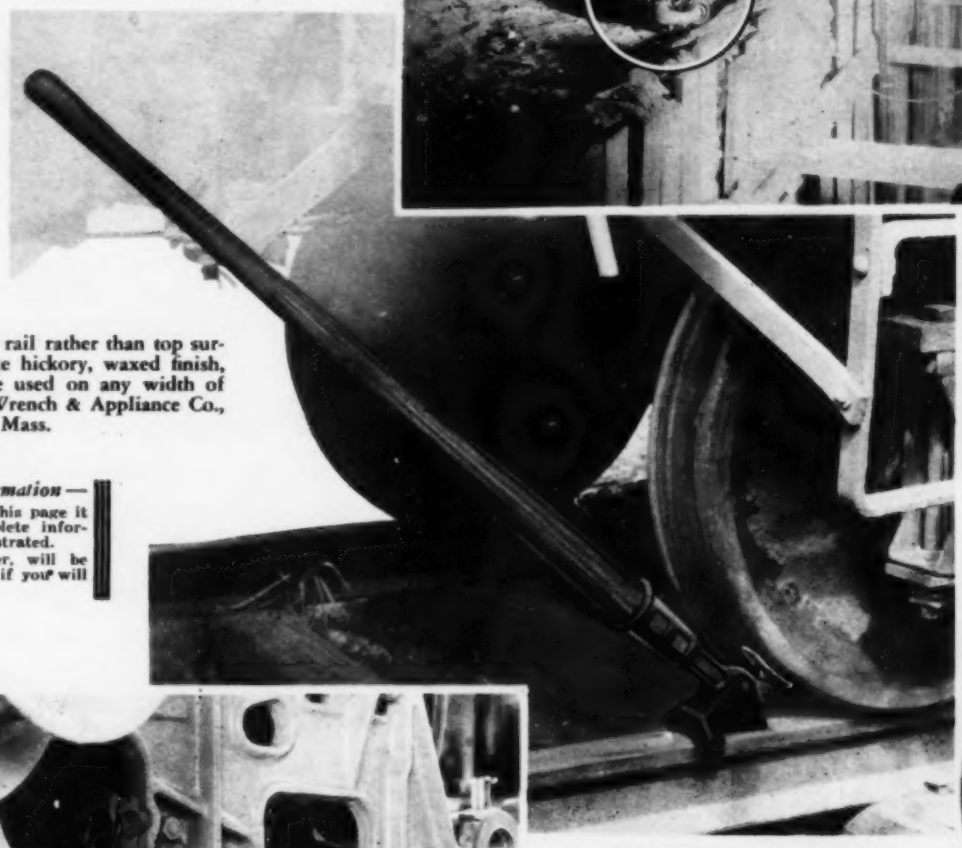


WELDING HELMET, for work in confined spaces, is designed to fit closely to face and sides of head without sacrificing ventilation or causing light leaks. Bakelite welding glass holder outside helmet fully dielectric, protecting wearer from burns in case of contact with electrodes. May be worn with respirator. Swivel connection permits helmet to be placed in three positions when in use.—American Optical Co., Southbridge, Mass.

LIGHTWEIGHT DRIFTER DRILL (126 lb.) of streamline design incorporates following features to make a machine of high speed, low maintenance cost and ease of operation: Automatic valve which gives high speed with low air consumption; special long-wearing bronze removable front cylinder lever; direct center exhaust; rugged throttle valve with outboard bearing; and threepoint crosshead support. Integral lubricator supplies lubricant to all parts of machine. May be equipped with spring handles for use as sinker.—Gardner-Denver Co., Quincy, Ill.



PORTABLE 1,250-W. GENERATOR AND FLOODLIGHTS speed emergency repairs and permit night construction. Machine weighs 89 lb. complete and can be carried by one man, is fully automatic and requires no adjustment. In daytime generator can be used for operating electric saws, drills, hammers, sanders, paint spray guns and other electrically operated equipment.—Homelite Corp., 73 Riverdale Ave., Port Chester, N. Y.

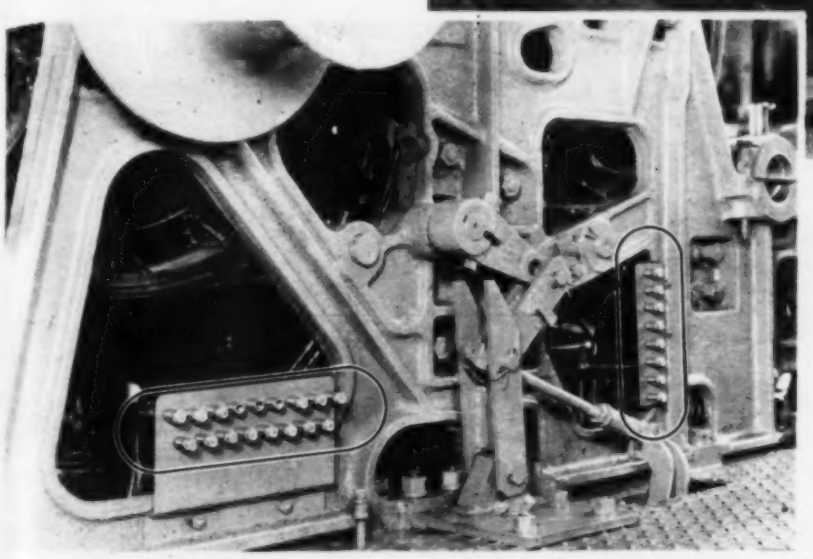


SAFETY CAR MOVER *(right)* gets under load and places handle in high position so that operator can use full strength in starting car. Spur plate has flanges and lug which clamp it securely to rail, holding spurs rigidly without imposing shearing stress on bolt. Special heat-treated alloy-steel spurs with four sharp edges are placed at extreme angle to grip corners of rail rather than top surface. Handle of selected white hickory, waxed finish, 53½ in. long. Mover may be used on any width of rail. Weight, 16 lb.—Safety Wrench & Appliance Co., Worcester, Mass.

If You Want Further Information —

Within the space limits of this page it is impossible to present complete information about the products illustrated.

The manufacturers, however, will be glad to supply further details if you will write to them.



DURABILITY, efficiency and usefulness of this chain hoist *(right)* have been increased by the following improvements on old model: Zinc coating of all exposed parts; ball bearings with integral grease seals for all moving parts with continuous lubrication of positively sealed precision bearings; hardened pawl tip; improved load chain guard, and ball spring covers on oil tubes.—Wright Mfg. Division of American Chain Co., Inc., York, Pa.

CENTRALIZED LUBRICATION is latest feature of P&H construction equipment. D. B. Patterson, Executive Vice-President of Harnischfeger Corp., states: "For years lubrication has been a constant bugbear on heavy construction equipment. Operators, busy with their own work either had to take time out or overtime to do this greasing and do it right. And frequently those hard-to-get-at parts got nothing but a 'lick and a promise'. We found the most effective way to overcome this difficulty was the convenient grouping of Alemite nipples in a more accessible place. This not only reduces time required in necessary lubrication, but assures a 100 per cent job by taking the drudgery and the chance for negligence out of the work."—Harnischfeger Corp., Milwaukee, Wis.

HEAVY-DUTY PNEUMATIC-TIRED TRAILER *(below)* at lower cost made possible by development of new tire for use on La Crosse Tu-Way machines. Tires are 10 ply and of 3,600-lb. capacity. Diameter, less than 30-in. With these tires, difficulties encountered by use of large pneumatics are eliminated. Loading platform less than 30 in. above ground permits easy loading over ends as well as over sides and makes possible use of stocky, sturdy wheel of unusual strength. Wheels are mounted on Timken bearings and have demountable rims.—C. R. Jahn Co., Builders Bldg., Chicago, Ill.

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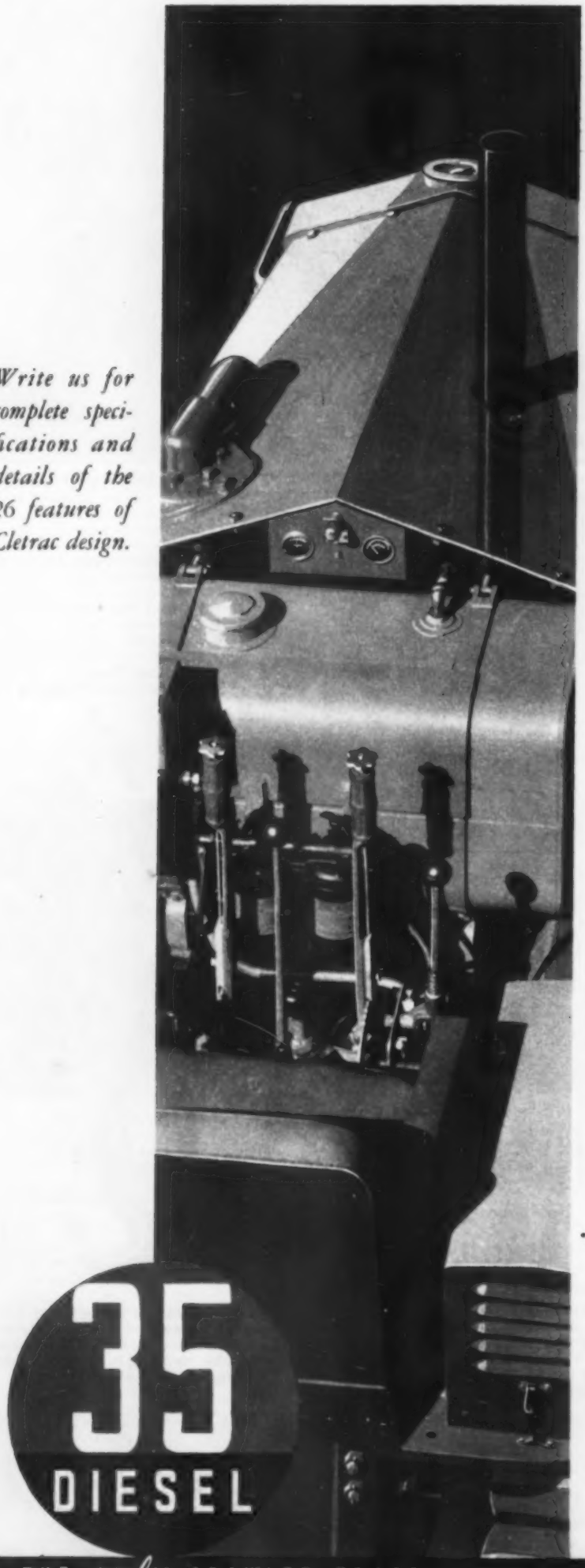

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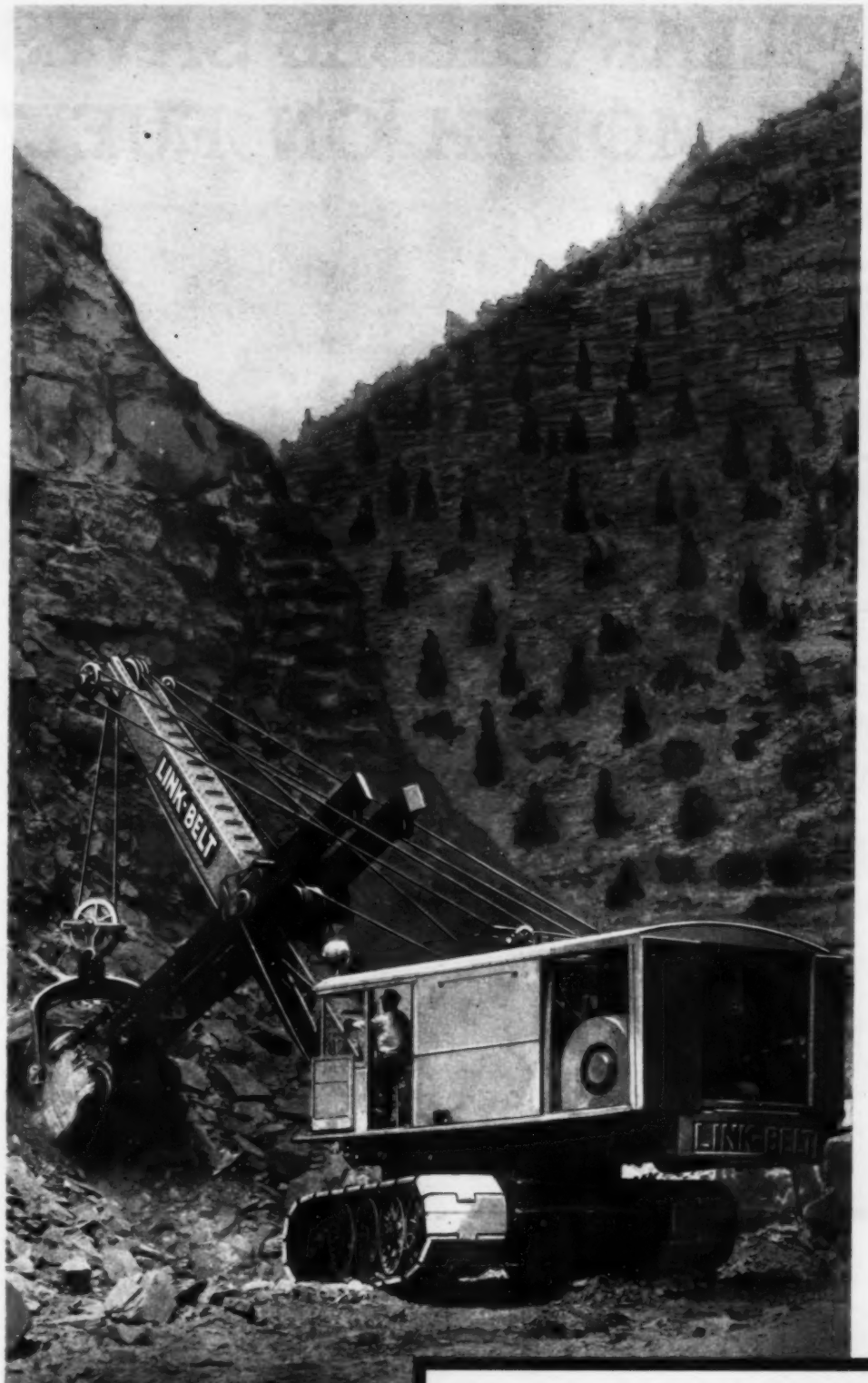

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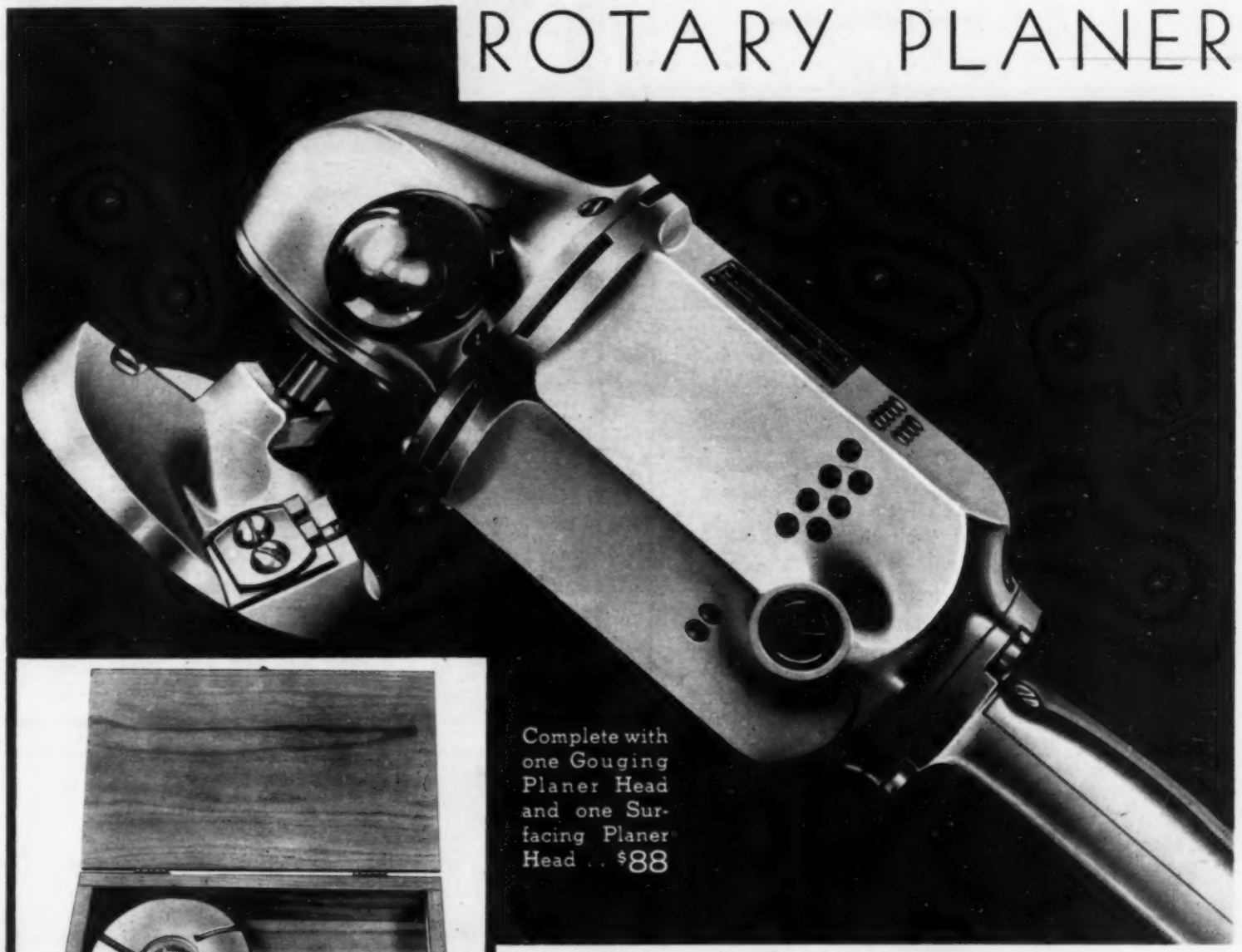

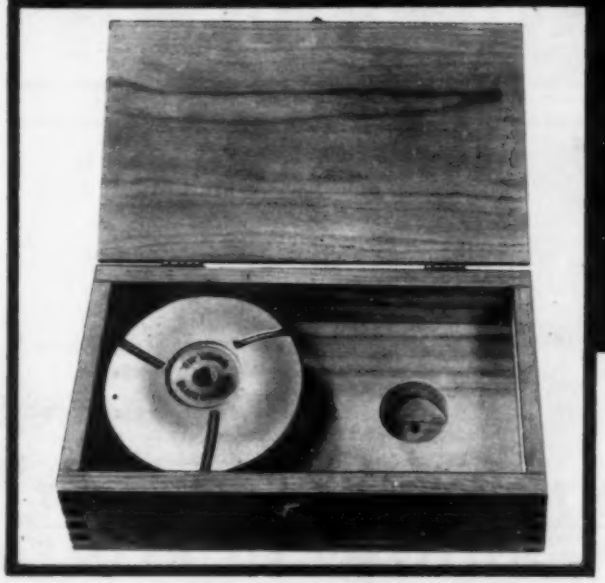

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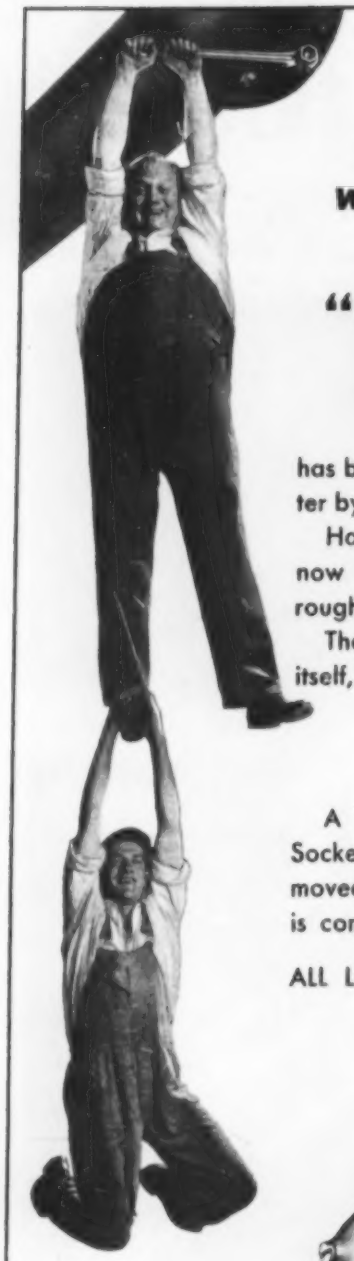

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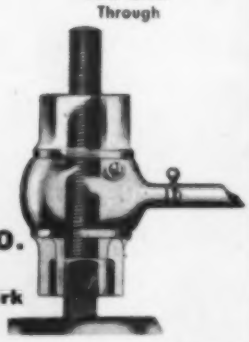

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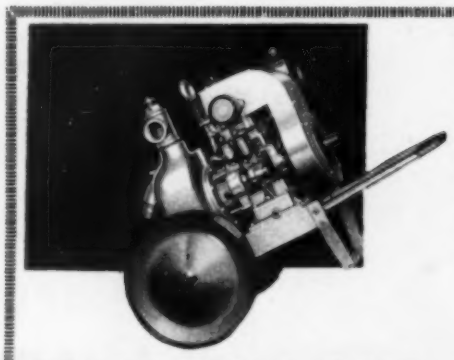

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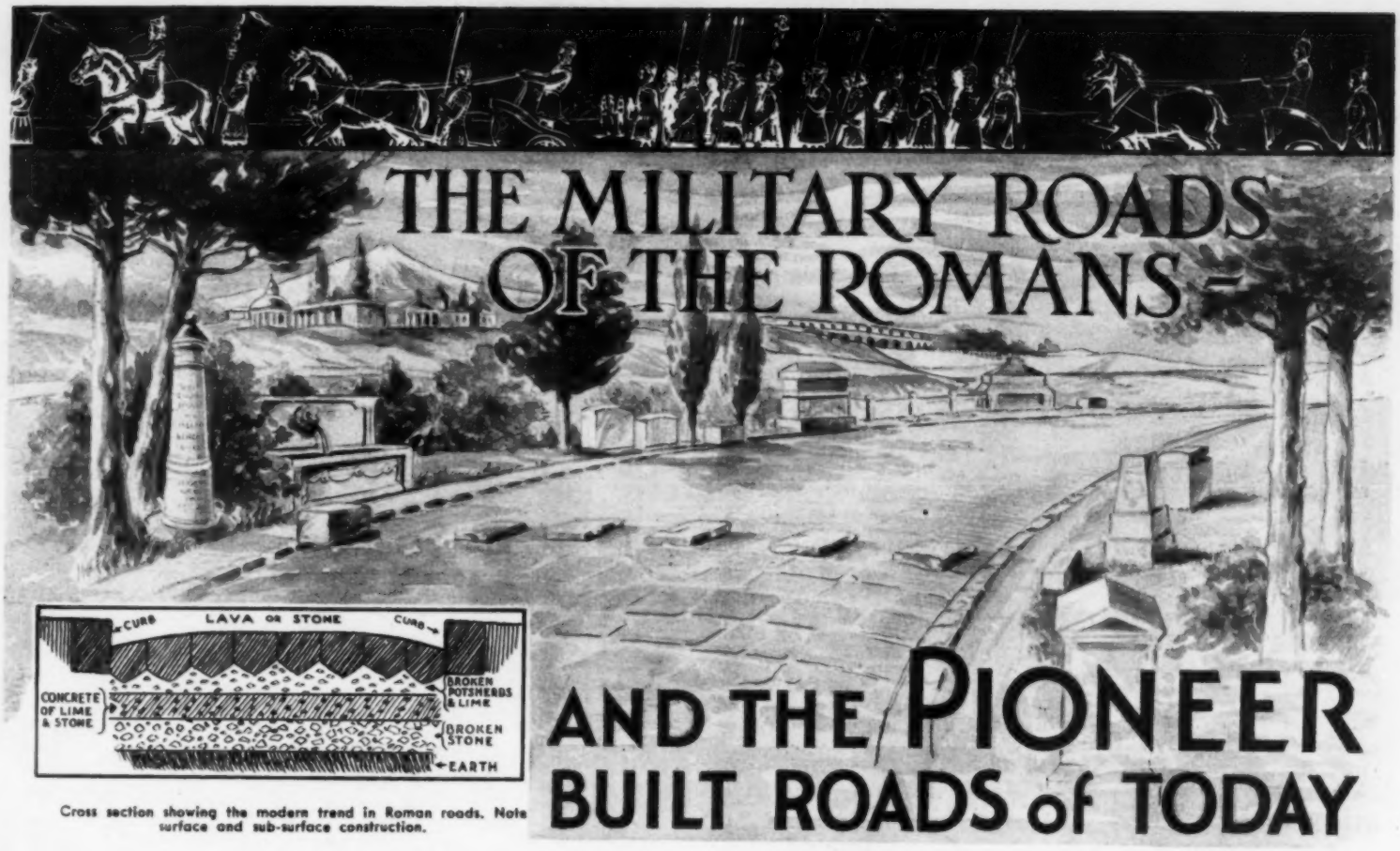

Cross section showing the modern trend in Roman roads. Note surface and sub-surface construction.

The engineering skill of the Romans and the lavish outlay of money made their military roads the best known of the world of their time.

Beginning with the first acquisition of territory in Italy—the Via Appia was built in 312 B.C. The Roman roads kept pace with the expansion of the Republic and the Empire. Roads were built at the cost of the state. In the provinces, the conquered communities bore the expense of construction and maintenance, but the work was done under the direction of Roman engineers and often by the legion between campaigns. Roads ran in straight lines between the towns they were to connect, with frequent cross and branch roads, less carefully constructed. No natural obstacles were permitted to change their course. The grade was always easy—hills being cut through, gorges and rivers crossed on arches of solid stone and valleys and marshes spanned by viaducts of stone.

Surface of roads was perfectly smooth and rounded off. Gutters at sides were provided to carry off snow and water. Milestones showed distance from starting point of road to that of important places in opposite directions, as well as the names of consuls and emperors under whom the roads were built.

The road bed was wide enough to permit the easy passage of two wagons. For pedestrians there was a foot path on either side with frequent stepping stones to permit crossing to other side above the mud or dust of the wagon way.

Such roads often went for years without repairs and yet some portions of them have endured for centuries and are still in fair condition today.

But—even Cæsar would have gasped at the thousands of miles of the great roads of today, bearing their constant succession of smashing traffic blows, and the day-long rip and tear of great speeding tires.

No slaves bend over our highways under the lash of conquerors. But we have the giant slaves of today—the modern portable ***Pioneer Gravel Equipment machinery.***

Pioneer 15 Duplex Screening, Crushing and Loading Plant: 15' triple deck SKF bearing shaker screen; 836 or 1036 SKF bearing jaw crusher; 40" diameter x 20" face Timken bearing roll reduction crusher with positive adjustment for size; V-belt drive between crushers; feeder and delivery conveyors in lengths desired.

Pioneer No. 12 Duplex owned and operated by P. C. Roth, contractor of Brainerd, Minn. This plant equipped with 1036 SKF bearing jaw crusher and 30"x 18" Timken bearing roll reduction crusher. This plant averaged 2¼ tons per minute of ¼" round minus, crushing 25% on surfacing project near Sebeka, Minn.

In building the wonder roads of today, Pioneer 15 Duplex Plants are consistently breaking one record after another. Large size Timken bearing roll reduction crusher and ample screening area — 28⅔ lineal feet — to take care of added crusher area, are two of the many exclusive Pioneer features. The Pioneer Duplex has more screening area and more crushing area than any other portable plant in existence — which means doing your job —

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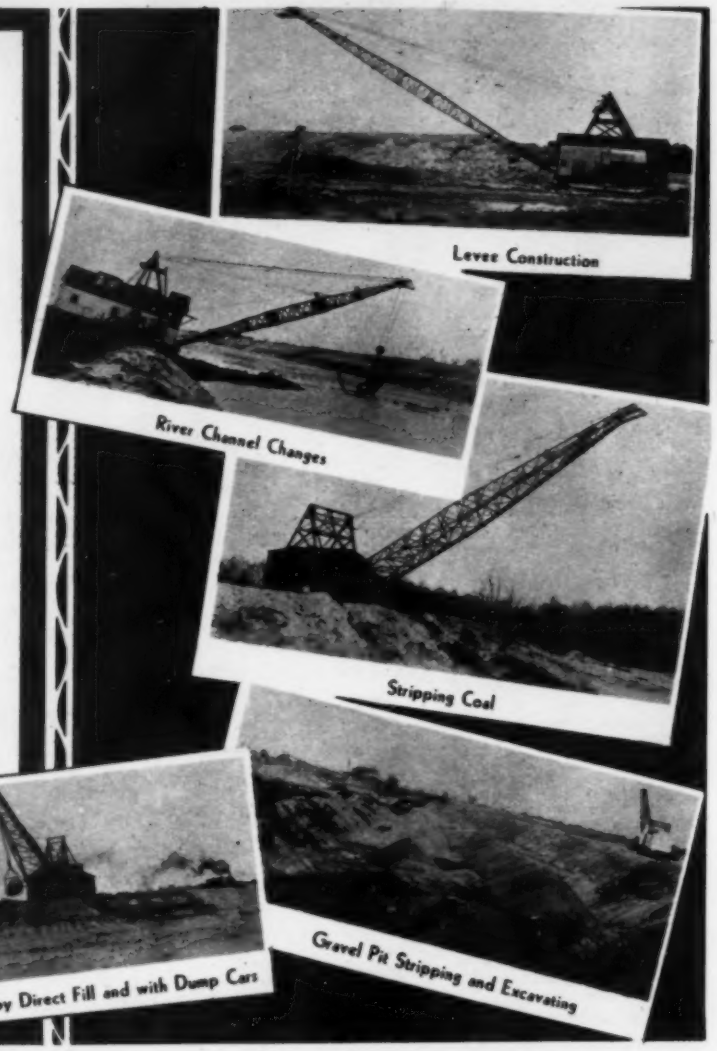

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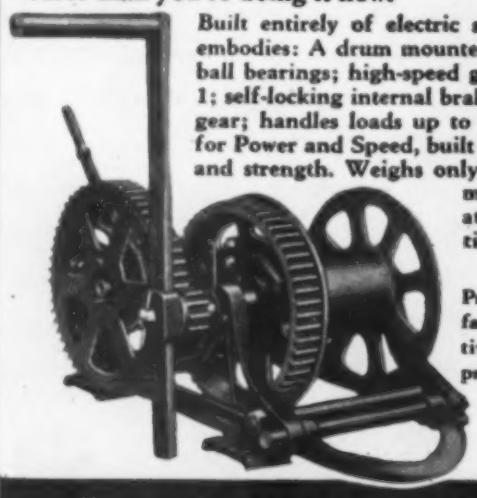

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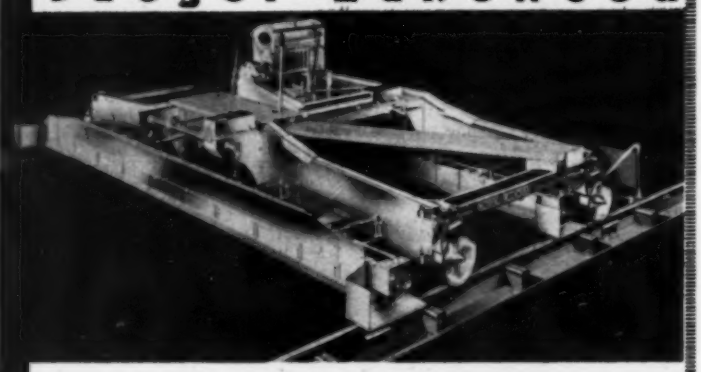

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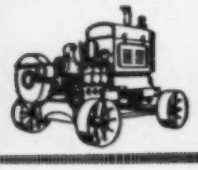

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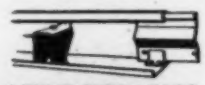

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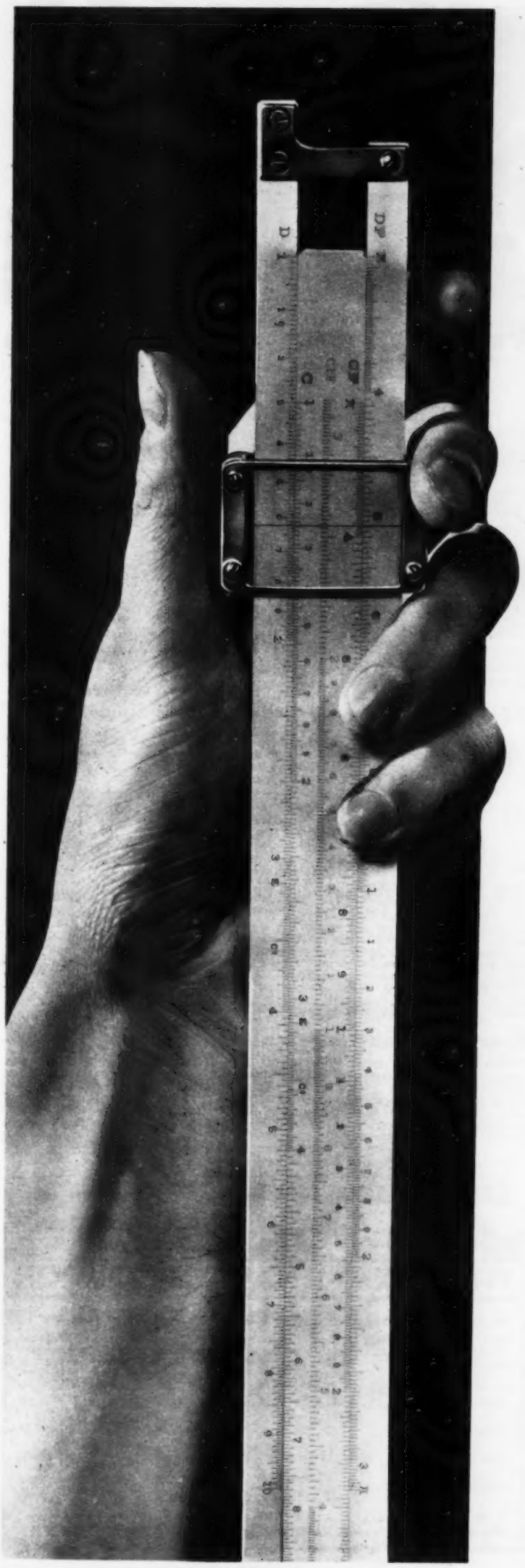

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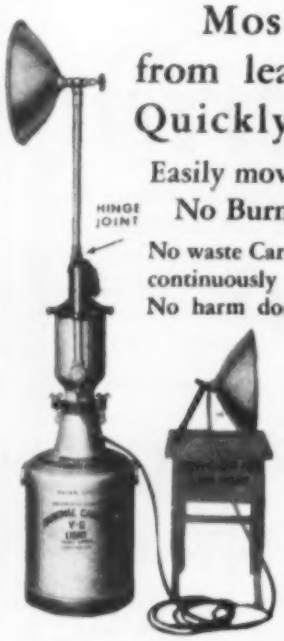

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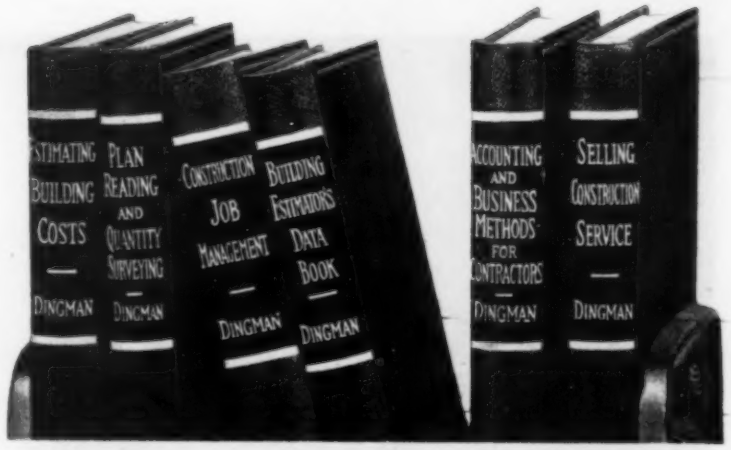

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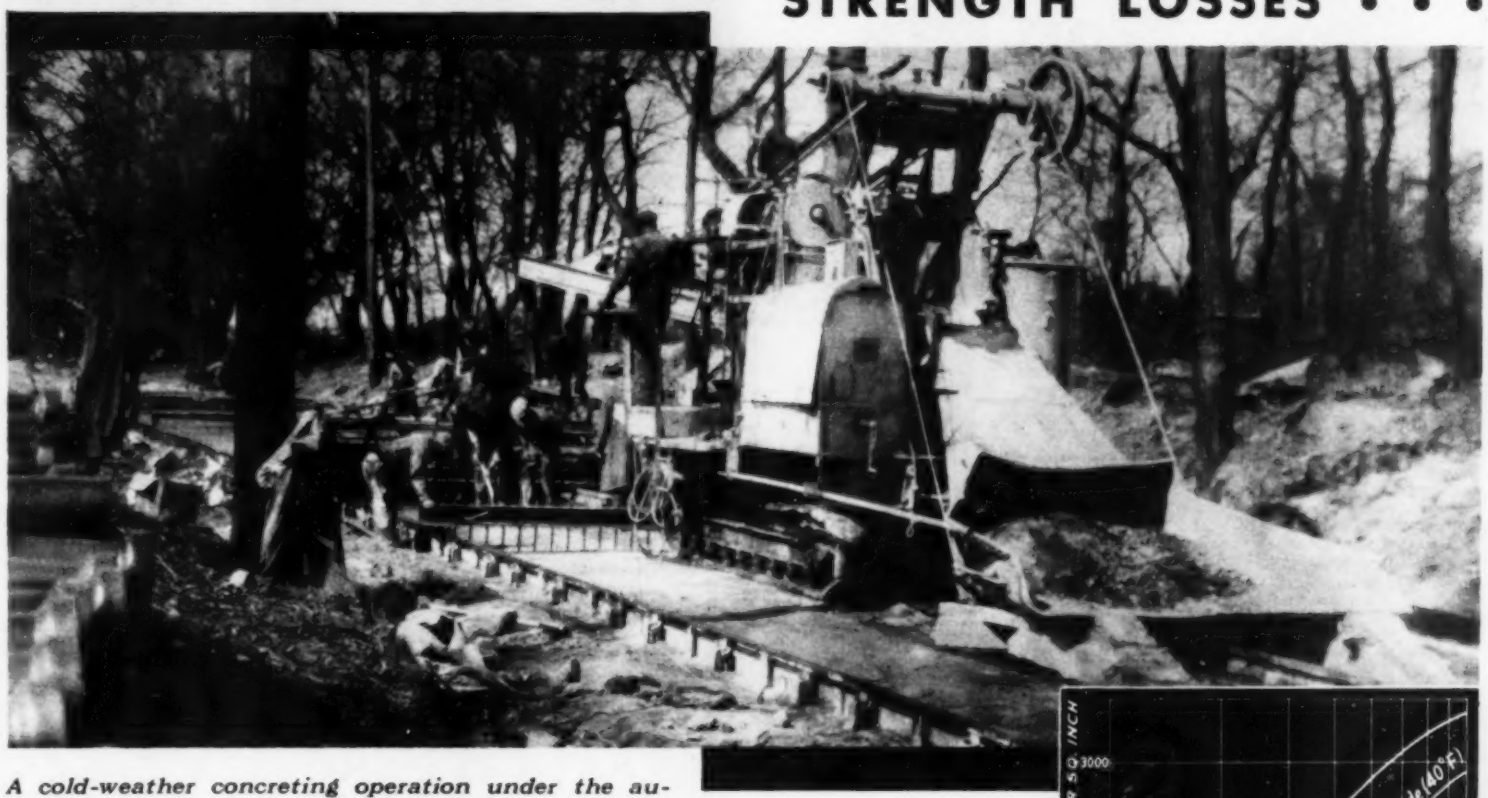

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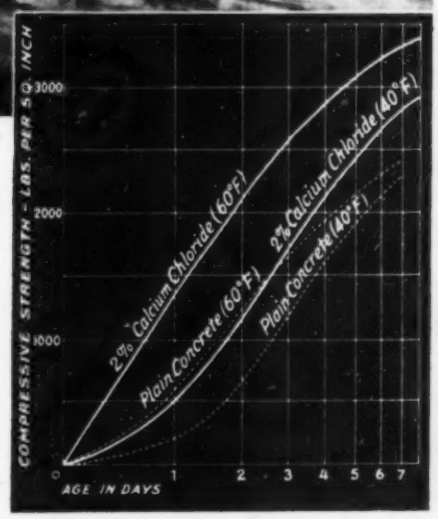
For literature and complete information on Calcium Chloride concrete curing—by the "integral" or "surface" method—write to any of the members of the CALCIUM CHLORIDE ASSOCIATION.



This chart, made from tests, shows Calcium Chloride cured concrete having twice the strength of plain concrete after the first twenty-four hours.

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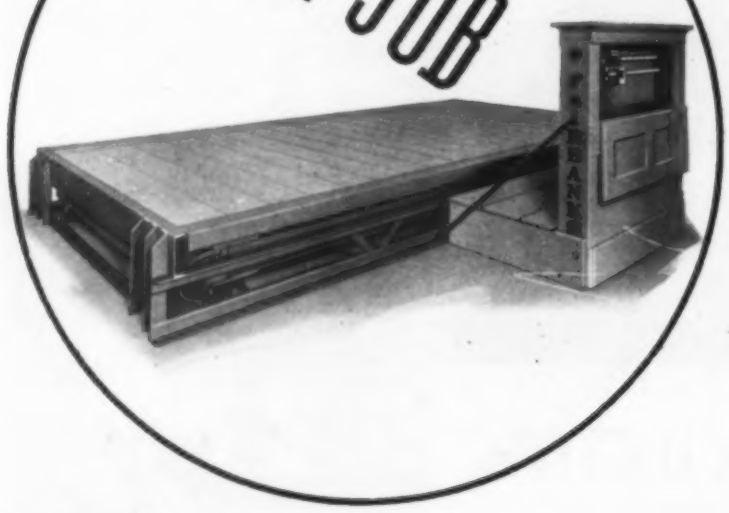

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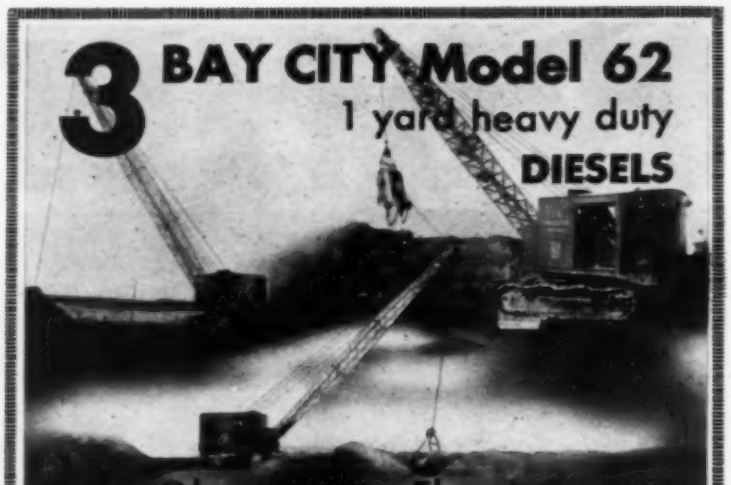

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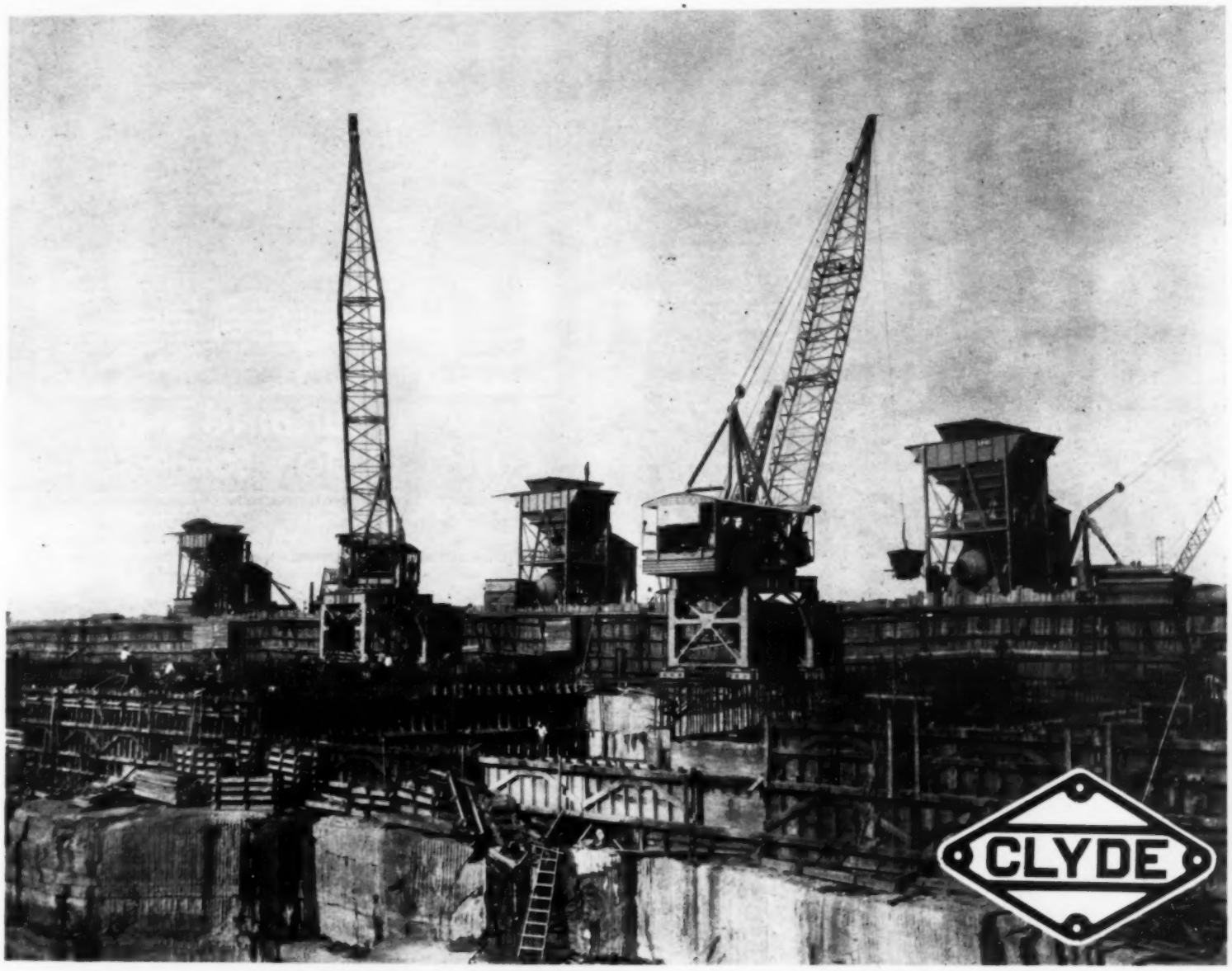

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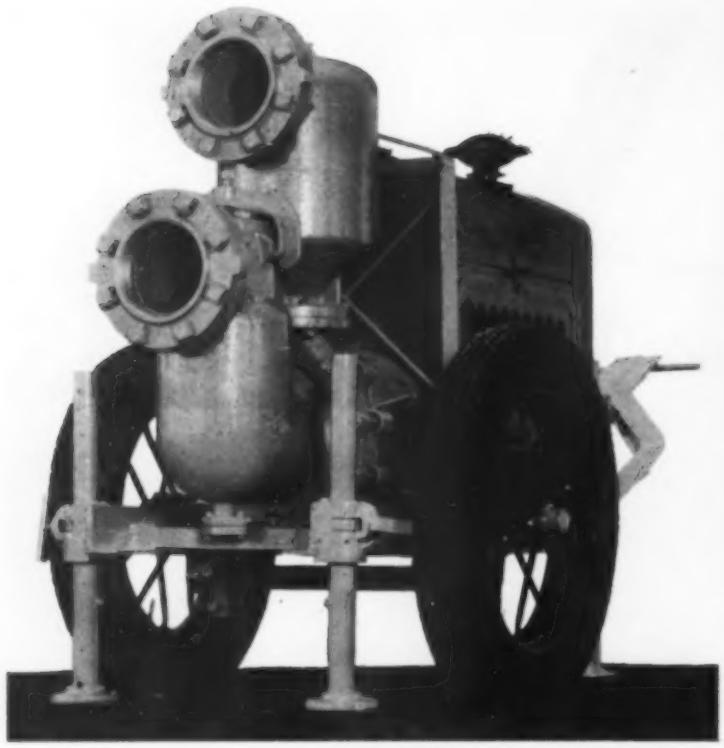

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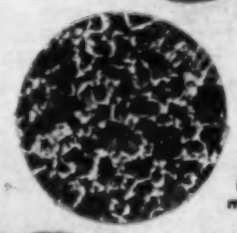
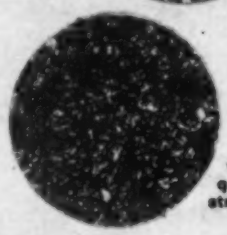
Micrograph made in the Bucyrus-Erie metallurgical laboratory showing BE-YZ steel as cast in the Bucyrus-Erie foundry.



Normalizing the steel in one of the annealing furnaces is the first step in the tempering process. Here is a micrograph of YZ normalized.



In the heat-treating plant internal stresses are further relieved and greater strength developed, so that this micrograph of YZ after quenching shows an entirely different grain structure.